A STUDY OF VACUUM ASSISTED CLOSURE IN CHRONIC NONHEALING ULCERS

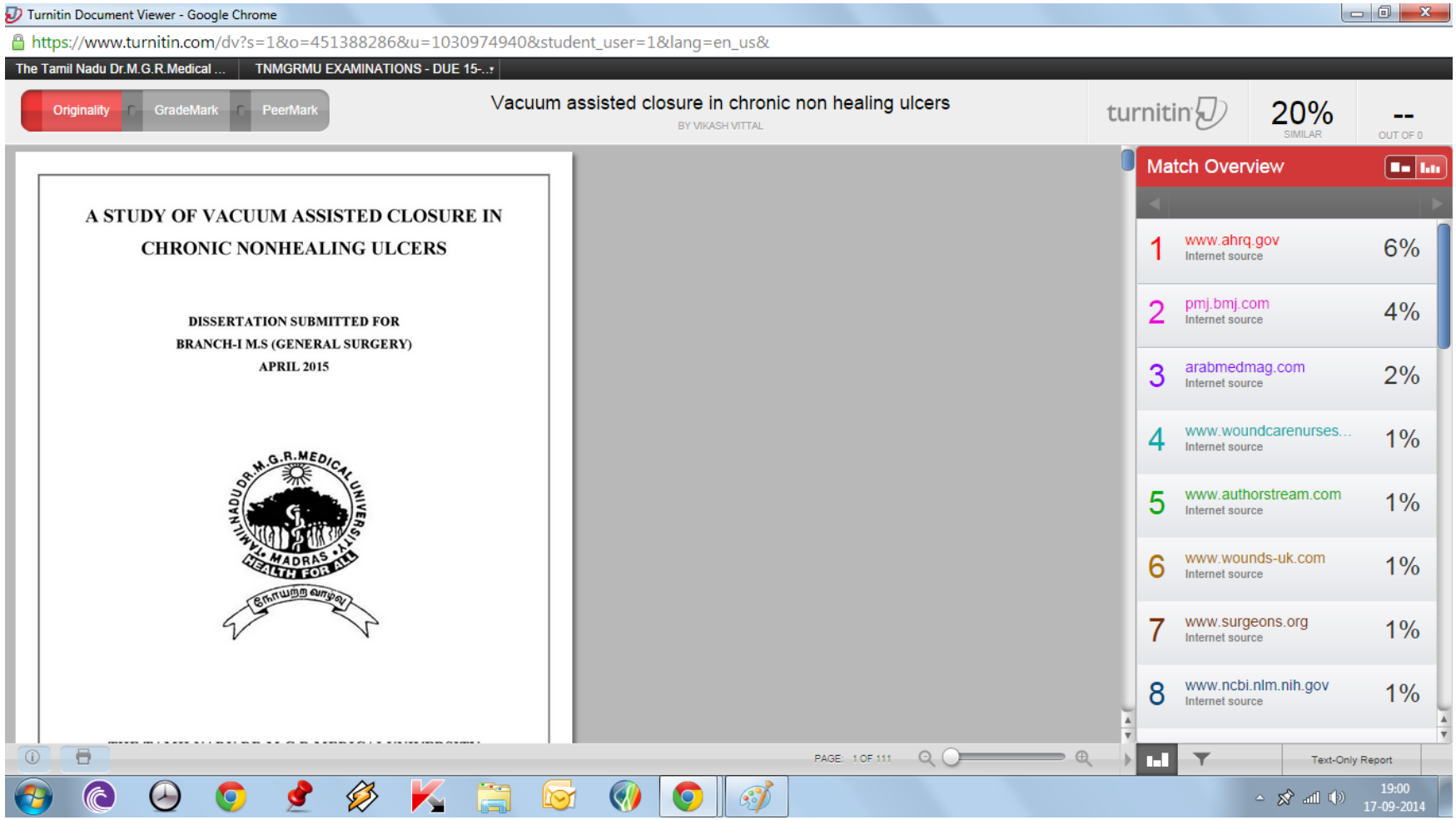
DISSERTATION SUBMITTED FOR

BRANCH-I M.S (GENERAL SURGERY)

APRIL 2015

THE TAMILNADU DR.M.G.R.MEDICAL UNIVERSITY

CHENNAI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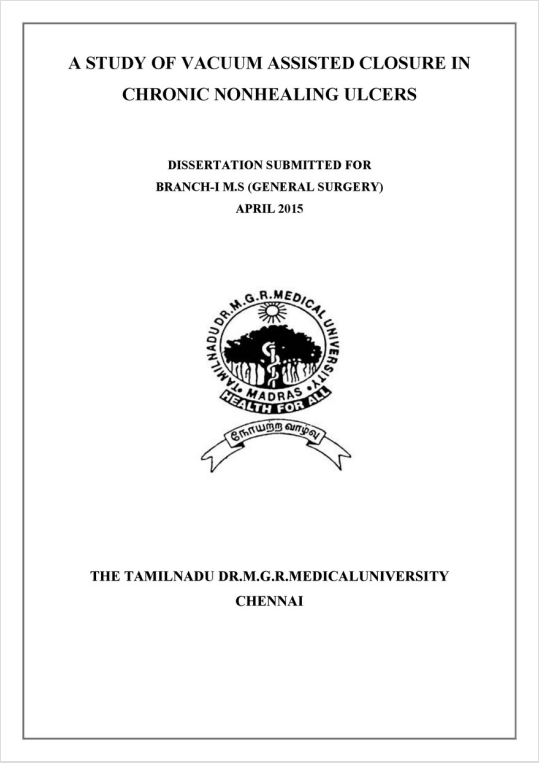

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DECLARATION BY THE CANDIDATE

I, **DR.VIKASH.V** here by solemnly declare that this dissertation entitled **" A STUDY OF VACUUM ASSISTED CLOSURE IN CHRONIC NON HEALING ULCERS."** is a bonafide and genuine research work carried out by me. This is submitted to The Tamil Nadu Dr M.G.R Medical University, Chennai, in partial fulfillment of the regulations for the award of MS degree (Branch I) General surgery.

PLACE:

DATE: Dr VIKASH.V

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TABLE OF CONTENTS

INTRODUCTION

Amongst the most common causes for admission in general surgical ward is chronic non healing ulcer of which diabetes is the most common etiology. In most of the cases, hospital stay of many weeks is required for management of the above. In many cases they ultimately go for amputation. A significant amount of people are affected by acute or chronic wounds. Unmindful of the cause, superimposed on this is the presence of factors like diabetes that impede the normal healing process.

Wounds do not only lead to hospitalization of the patient but also lead to consequences like amputation of the limb and at times,even death and from the patient's view, wound therapy is often un-comfortable or painful. In all sense patient's turns to be a burden for society and family.

Vacuum assisted closure is a universally accepted method for dressing. It has proved its efficacy for wound dressing, faster wound healing and shorter hospital stay.

Still in our hospital, majority of dressings are conventional. Aim of study is to show the advantage of V.A.C. over conventional dressing in our hospital.

The requirements are a piece of foam, some perforated plastic tubing and with it,a suction machine. The foam is placed over the wound and the wound is covered with an occlusive dressing; by doing this we convert an open wound into a closed

controlled wound wherein vacuum can be created through the perforated plastic tubing with a suction machine and the whole apparetus was developed into what is now referred to as vacuum-assisted closure (VAC).

The purpose of this type of wound management is to decrease wound healing time and to facilitate wound care in situations that otherwise might be considered difficult or nonhealing. Of late,the Negative Pressure Wound Therapy(NPWT) has become a very commonly used method because of its lack of complications and effectiveness in complex situations.

NORMAL WOUND HEALING

Wound healing can be considered as body's response to any form of injury. Phases of wound healing are presented as separate events, however these events do not occur independent to one another and there is a significant degree of temporal overlap. Emphasis is on the underlying physiologic process and the pattern of responses with surgical applications. Every tissue in the human body undergoes a reparative process after sustaining injury amongst which bone has a unique ability to heal without scar.

The PROCESSES OF WOUND HEALING take place in an overlapping and sequential manner

- Coagulation
- Phagocytosis
- Chemotaxis
- Mitogenesis
- Collagen Synthesis
- Extracellular Matrix Synthesis
- Contraction

PHASES OF WOUND HEALING

1. Hemostasis and inflammatory phase
2. Proliferative phase
3. Maturation and remodeling phase.

INFLAMMATORY PHASE

The inflammatory phase of healing in an acute wound begins instantaneously after injury. The initial response when a blood vessel is disrupted is bleeding. The hemostatic response to this is clot formation in order to stop hemorrhage from the wound. Platelet plug formation marks the initiation of the hemostatic process

along with the clotting factors activated by collagen and basement membrane which was exposed by the injury.

After any injury, transient vasoconstriction occurs which is mediated by catecholamines, thromboxane and prostaglandins (PGF2). Platelets degranulation occurs thereby emptying the granules into the extracellular space, which contain alpha granules and dense granules, most important of which are platelet derived growth factor (PDGF) and transforming growth factor beta (TGF beta). PDGF and TGF beta then initiate the inflammatory response by bringing about chemotaxis and also the proliferation of inflammatory cells.

At the site of injury,initially transient vasoconstriction occurs,thereby causing a reduction in the blood flow at the site allowing the formation of clot at that site. This is further followed by vasodilatatioin which aids in transmitting substances needed for repair of wound.Vascular endothelial cells play a vital role in altering the permeability of the patient...

At this stage, the wound is filled with debris from the initial injury.

It consists of a mixture of

1. Injured and devitalized tissues (epithelium,fat and muscle)
2. Clot (fibrin,erythrocytes and platelets)
3. Bacteria (from the external environment)
4. Extravagated serum proteins
5. Foreign materials

PROLIFERATIVE PHASE

Macrophages at the site of injury produce growth factors. These growth factors induce the proliferation of fibroblasts which form a matrix of fibrin and fibronectin . This initiates the proliferative phase and thereby marks the first step in the stages of clot formation on the wound. The growth factors produced by these macrophages also induce angiogenesis. At this point of time, fibroblasts remain to be the most dominant cell on the wound. Angiogenesis is characterized by formation of new capillaries induced by the formation of endothelial cells. which thereby induces further ingrowth and proliferation of the endothelial cells. This neovascularity that occurs is clearly visible through the epithelium and it gives the wound a purple red appearance. The newly formed capillaries thereby deliver the sufficient oxygen and essential nutrientshaving been provided with the requirements,the cells continue to proliferate and lay down the permanent wound matrix. The matrix that is finally laid down is predominantly composed of proteoglycan and collagen.

The four major events in proliferative phase are

- Angiogenesis
- Fibroplasia
- Epithelialization
- Contraction

ANGIOGENESIS

Angiogenesis is referred to as the process of formation of new blood vesssels.

Various steps involved in angiogenesis are

1. The basement membrane of the post capillary venules degrade
2. Fibroblast growth factor(FGF), Platelet derived growth factor(PDGF) and Transforming growth factor(TGF) stimulate the migration of cells needed for angiogenesis through the basement membrane
3. Interaction of the cells that migrate through the basement membrane
4. Cell-cell and cell-matrix interactions which lead to tubule formation
5. Differentiation of these newly formed capillaries into venules and arterioles
6. Maturation of the capillaries by deposition of BM

FIBROPLASIA

This phase starts with degradation of the initial fibrin-platelet provisional matrix. During fibroplasia, the fibroblasts synthesize and deposit the replacement extracellular matrix at the wound . As these fibroblasts proliferate, they become the predominant cell types by three to five days in non- infected wounds. The fibrin matrix initially deposited is replaced by a provisional matrix

consisting of fibronectin and hyaluronic acid which facilitates migration of fibroblasts. Specialized cells that differentiate from resting mesenchymal cells in connective tissue. They do not arrive in the wound cleft by diapedesis from circulating cells. After injury, the fibroblasts that are normally quiescent and sparse are chemoattracted to the inflammatory site, where they divide and produce the extracellular matrix. Normally arrested in the G0 phase, they undergo replication and proliferation after stimulation by the macrophages and platelet-derived cytokines and growth factors. It is the time that undifferentiated mesenchymal cells take to differentiate into highly specialized fibroblasts is what that accounts for the delay between injury and the appearance of collagen in a healing wound.

EXTRACELLULAR MATRIX

Extracellular matrix are molecules that are present in the extracellular space. These molecules are secreted locally and aid in offering support and also play an important role in interactions between cells. Basement membrane and interstitial matrix constitute the extracellular matrix.

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Functions of ECM:

- ECM withdraw the excess amount of water from the soft tissues that help in keeping the skeletal tissues rigid
- Storage of growth factors that play a major role in proliferation of cells

- Provides intercellular communication .

Components of ECM

1. Fibrous structural proteins like collagen and elastins
2. Adhesive glycoproteins / Cell Adhesion Molecules(CAMs)
3. Hyaluronic acid and proteoglycans
4. Basal Lamina

GRANULATION TISSUE FORMATION

Granulation tissue is a framework that is formed by fibronectin,hyaluronic acid and collagen over which newly formed blood vessels,extracellular matrix,fibroblasts and macrophages are deposited. A granulatiuon tissue appears beefy red and is a very healthy and good proghnostic sign that a wound is flourishing and suitable to be given a cover either by a split skin graft or a flap. he platelet and activated fibroblasts and macrophages

EPITHELIALIZATION AND CONTRACTION

Epithelialization followed by contraction and scar formation are two different processes. Whereas the former does not exhibit any new tissue formation the latter has scar formation. There is a significant degree of time that is associated with scar formation while contraction happens in a lesser time interval. In epithelialization and contraction,the skin all around the wound grows in towards each other and results in

approximation thereby closing the wound in a primary intention.

In human beings, contractions happen to the greatest degrees in the trunk and perineum, intermediate on the head and neck and least on the extremities.

There is no clear understanding so far regarding the cellular mechanism involved in the process.

I. Myofibroblasts which happen to be fibroblast like cells play a very important role in contraction of the wound. Their mainly made up of actin and microfilaments in their cytoplasm.

II. In order the wound to contract,there must be cleavage of the plane between the fibroblast and collagen thereby allowing contraction of the lattice and also the wound. This is brought about my Membrane mettaloproteinases like Stromelysin-1.

Wound contraction must be distinguished from contracture.

Wound contracture is different to scar contracture. Any reduction in size of tissue overlying a joint results in compromise of the joints mobility. This is what is referred to as joint contraction whereas reduction in the length of the scar as compared to its initial length.

The basal cells that are present in the margin of wounds are the

sites of initiation of wound healing and scar formation. The basal cells that are present in the margin migrate inward into the wound to cover its surface. The keratinocytes are quiescent and do not multiply until epidermal continuity is achieved. The basal cells that migrate over the wound surface are known to do so in a leap frog or tumbling motion. The cell adhesion glycoproteins,tenascin and fibronectin guide these keratinocytes over the surface of the wound thereby acting as their "railroad tracks".

Following the establishment of the epithelial layer,the next process is the formation of the basement membrane. This is brought about by the laminin and collagen type IV which are produced by the keratinocytes. The keratinocytes then transform into columnar cells and active division takes place in them which helps in re-establishment of the epidermal layer . The keratinocytes that migrate separate the desiccated eschar tissue from the healthy tissue If the continuity of the keratinocytes has been established and the basement membrane formation is complete, the epithelialisation process takes place in a swift manner.

After complete re-epithelialization of the wound, the cells become stratified columnar again .this brings about a firm attachment between the re-established basement membrane and the underlying dermis.

REMODELING PHASE

Remodeling phase is the stage in wound healing that takes place after wound contraction. Collagen is a major constituent of the extra cellular matrix. The lysl

oxidase that is a component of collagen is very important in establishing cross linkages between cells.this conspicuously increases the tensile strength of the wound.

The collagen is densely packed in the scar tissue whereas the pattern is reticular in the unwounded dermis . There are no epidermal appendages like hair follicle or sweat glands in a scar.

The process of remodeling takes a fairly long time to produce a mature scar.The early scar is red in colour because of the colour imparted by the dense capillary network that was formed during the time of injury. A completely matures scar is commonly hypopigmented. This scar later becomes hyper pigmented in people eith darker complexion and people who hace a constant exposure to sunlight[4,5]

FACTORS AFFECTING WOUND HEALING

Local factors:-

- Surgical technique
- Tissue vascularity
- Mechanical stress
- Movement
- Extent of wound surface
- Foreign bodies
- Extent of wound surface
- Oedema and Dehydration Wound infection

- Local irradiation
- Suture material and techniques
- Foreign bodies
- Haemorrhages

Systemic factors:-

- Age
- Obesity
- Malnutrition
- Vitamin deficiancy
- Anaemia and hypoxia
- Systemic disease
- Temperature

CLINICAL IMPLICATIONS

- Atraumatic handling of tissue decreases the number of non viable and necrotic cells at the wound margin.
- Fat is devoid of collagen and does not hold tension. Hence fatty tissue should not be sutured as a separate layer.
- Dead space obliteration and fluid evacuation are best achieved by suction drainage rather than adding additional foreign material to the wound in the form of suture material

- Under normal circumstances, epithelialization of an incision is usually complete within 24 to 48 hours, and there is no need to protect the incision from contact with water beyond this time. Allowing patients to wash 1 or 2 days after surgery has significant psychological benefit and gently debrides the incision and keeps it clean by rinsing away surface bacteria and debris.

- Showers reduce the chances of bacterial accumulation in surface crusts along the incision and on sutures. This decreases inflammation and prevents breakdown of fragile epithelial layer over incision, improving the quality of the scar.[6]

Wounds are wide in distribution and they pose a serious problem in the community. they compromise patient mobility and are time consuming in treating. The wounds may be associated with a large number of medical, surgical and dermatological conditions and their origin is multifactorial. Wounds are of various etiologies and are on the increase in part with the increased incidence of variety of associated diseases like diabetes mellitus, arterial diseases, venous diseases, metabolic diseases, neoplastic conditions, etc.[7]

Wounds are classified as acute or chronic. Wounds less than eight weeks duration are termed acute . They have not yet completed the natural healing cycle. Chronic wounds are those that have failed to proceed through an orderly and timely process that produces anatomic and functional integrity . Chronic wounds either require a prolonged time to heal or they do not heal completely.[8]

CLASSIFICATION AND CAUSES OF WOUNDS

1 Traumatic

Thermal Burns, Decubitus, Radiation, Mechanical

2. ***Vascular***

Arterial

Atherosclerosis,Vasculitis,Buergers Disease,Raynaud's Disease

Venous

Varicose ulcer,Chronic venous insufficiency

Lymphatic

Chronic Lymphedema

3. ***Infective***

Pyogenic

Syphilis,TB

Tropical Diseases

Fungal Diseases

4. ***Neoplastic***

Skin tumours

Metastatic

Kaposi's Sarcoma

5. ***Systemic-Metabolic***

Ulcerative Colitis

Diabetes mellitus

Sickle Cell Disease

6. ***Neurotrophic***

Cord Lesions

Peripheral Neuropathies

MANAGEMENT OF WOUNDS

Healing process of a wound is a highly orchestrated process, which commences with removal of all debris and then control of infection. Inflammation clears the area for new blood vessel growth to occur in order to increase the blood flow to the wound. Following which, the wound heals through deposition of granulation tissue and wound contraction and maturation. Failiure of one of these steps prevents the wound from healing. Other factors such as diabetes mellitus, vascular disease, pressure, trauma, venous insufficiency and prolonged immobilisation will impede wound healing.[9]

Conventional treatment for all established wounds incorporates common principles of wound management including debridement of necrotic tissue, maintenance moisture in the wound bed and infection control. These common elements of wound care are combined with treatment modalities specific to the wound type and the clinical features of the patient[10]. The setting in which the wound is being treated varies widely,ranging from home treatment to specialized wound treatment centers. Most of the non healing wounds usually heal with adequate trial of optimal care. The variability in prior care offered is also a concern for clinical trials, as this variability contributes to the heterogeneity of the sample in study.

Standard wound management consists of initial thorough surgical debridement thereby removing all devitalised tissue[11], then either wet-to moist gauze dressings, which need to be changed at least twice a day can be used to cover the wound (Joseph 2000). These dressings are readily available, easy to apply and relatively inexpensive,. Vacuum-assisted closure has been suggested as an alternative that may promote faster wound healing with fewer painful dressing changes.

AIM OF STUDY

AIM OF STUDY

- To study the advantage of vacuum assisted closure over conventional dressing in the management of chronic non healing ulcers.

- To study the difference in rate of amputation, hospital stays in case and control gropus.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Negative pressure wound therapy (NPWT),which first developed at Wake Forest University (Winston-Salem, North Carolina) in the early 1990s, consists of an open-cell foam dressing covered with an airtight adhesive drape. The dressing is connected to a vacuum pump that creates and maintains over the wound, a sub atmospheric pressure (intermittent or continuous).

Several thousand NPWT applications are being performed each day all round the world especially in the United States. The most commonly used NPWT device is the (VAC) vacuum- assisted closure device. From 2003 to 2004, revenue for vacuum- assisted closure increased by 45% to about $700 million. Clinical knowledge regarding the management of difficult wounds is still limited owing to the lack of substantial high quality evidence.

The initial device consisted of a piece of foam, embedded plastic tube and a suction device. The foam is initially placed over the wound and wound is covered with an adherent, occlusive dressing; thereby converting the open wound into a closed controlled wound where vacuum can be created through the plastic tubing with the help of a suction machine and the whole system has been developed into what is now established as the vacuum assisted closure (VAC) device

The purpose of this type wound management is to decrease wound healing time and to facilitate wound care in situations that otherwise might be considered difficult or non healing. It has become a favoured method for wound management

because of its simple nature and ability to mange complex wounds with high efficacy. In addition, numerous other applications have been reported, ranging from treatment of wounds with exposed bone, tendon, or hardware, to management of acute burns, or even as an adjunct to skin grafting and artificial dermis grafting.

HISTORY OF V.A.C.

Thousands of years ago, the Chinese were applying cups that contained heated air to wounds so that, when the air inside the cups cooled, there would be slight reduction in pressure.

NPWT was first used successfully in the early 1950s to manage exudate and accelerate the process of wound healing (Raffel, 1952; Silvis et al, 1955)

Chariker et al (1986) described a simple but unique technique in which a drain tube that was wrapped in gauze was used to assist in the treatment of wounds that were complicated by draining enterocutaneous fistulae.

The initial achievements that were pretty significant in wound management and thereby surgery was the cleanliness of the wound(Pare I 1545) and removal of pus (Lister 1867) . There have been many giant leaps in the area of wound managements. All these advances are mainly due to the thorough and complete understanding of the patterns involved in the process of wound healing. An analytical approach is now adapted for wound management that is the consequence of years and years of research and pragmatic experience. All these novel methods have not only

improved the efficacy rates of wound care but also been able to handle complicated situations.

One among the newest concepts that is being brought into practice and will tend to change the phase of wound management from now on include is the Negative Pressure Wound Therapy(NPWT). It is quite a known fact that sub-atmospheric pressures applied at the wound site will tend to drain all the unwarranted fluid that accumulates and thereby impeding a healing process and also it influences of growth of the cells thereby bringing about re-epithelialistaion by now . Considering the positive effects of creating a negative pressure by connecting to a drain is good if thee drain is large in volume and intensity and taking that into consideration, a buried drain is not going to cause much of a harm and can be retained in place until wound heals delivering negative pressure.

Evangelista Torricelli is credited with introducing the first man-made vacuum when he turned over a column of mercury in a glass tube yielding the world's first barometer (and ultimately lending his name to common unit of air pressure). Since that time, numerous uses for this intriguing physical state have been discovered.

The application of NPWT in order to promote wound healing was first described in Russian medical literature for patients having infected breast wounds. These original reports actually described the application of a topical suction-cup-type apparatus to the surface of the wound to create negative pressures of around 80mm Hg (1,2) Subsequent reports have described the successful management of EC

fistulae and open abdominal wounds using flat drains that delivered negative pressure under compliant plastic films (3-5). In these reports surgical gauze was being used to create an interface between the surface of the wound and the vacuum source.

In western medicine, the first use of a vacuum in suction bells popularized in the nineteenth century by Junod (1)

The concept of applying sub atmospheric pressure to a wound bed was proposed more recently in 1993 by Fleischmann and colleagues (2), who described a technique of porous polyvinyl alchohol foam wrapped around suction drains, which were introduced into a wound sealed with a polyurethane drape and attached to a suction apparatus at 600 mm Hg. Fleishchmann et a1 (1993) carried out the first investigative studies into NPWT using foam as a wound contact layer. This description in German presented 15 patients who had open fractures that were treated in this manner. No infections were noted in this group, and an apparent increase in granulation tissue formation was described.

In 1997, Drs. Louis Argenta and Micahel Moryk was (3) presented their experience using the vacuum- assisted would closure device (VAC : KCI, San Antonio, Texas) They presented their 9- year experience with 175 chronic wounds, 94 sub acute wounds, and 31 acute wounds. In a simultaneous second paper, they presented their animal laboratory experience over; the same 9-year period(4).

In these landmark studies, wounds had enhanced granulation tissue and all were treated successfully to closure of the wound. The investigators noted that the wound care system effectively managed difficult wounds with ease and postulated that the technique improved local blood flow, removed chronic edema, and reduced bacteria counts in the wound bed.

More important advances in wound management have occurred recently as a result of expansion of knowledge regarding healing process at the molecular level. This has lead to the development of wound care methods which have greatly improved the capability of wounds to heal with lesser complications. A orchestrated approach to wound care has developed through extensive research. This has resulted in the development of efficient wound care algorithms and thereby creation of a reconstructive ladder in surgical practice.

The concept of using vacuum to create a suction force which would enable the drainage of wounds to promote wound healing is quite well known. If excess fluid is not sufficiently removed from a wound after surgery, its components may serve as both physical and chemical obstacles to wound healing. To add up on it, the basic concept of mechanical forces influencing the growth and shape of tissues is well reported. A buried drain can have negligible affect on surrounding tissue. Thus the development of application of suction topically across the wound surface to provide a solution that is capable of removing excess fluid and ECM and promoting a reduction in wound size.

REQURIEMENTS FOR OPTIMUM HEALING OF AN OPEN WOUND

There are numerous requirements for rapid and proper healing of an open wound.

Healing by "primary intention" - The edges of the wound must be allowed to seal back together

Healing by "secondary intention"- Granulation tissue must form to fill the wound bed .

Secondly , the wound must stay moist because the new epidermal cells can travel across moist surfaces only.

Thirdly, bacterial infection of the wound must be prevented by not allowing contaminants to reach the surface.

Fourth, any excess fluids must be removed from the wound surface while appropriate moisture is maintained.

Last but not the least, contributing factors to wound occurrence should be minimized, if elimination is not possible. Bedridden patients may be needing special support surfaces; protein caloric malnutrition and vitamin deficiencies should be adequately corrected and drugs know to impede wound healing should be adjusted.

Most wound tend to be either "contaminated" or "colonized" by bacteria that do not necessarily invade the tissues. The "critical colonization" concept has been introduced in the recent years in order to convey that bacterial growth may actually play a role in the delayed healing of wound even in the absence of the traditional criteria necessary for infection. Approach to reduce the volume or "density" of bacteria present in a noninfected wound includes the use of wound irrigation with the help of normal saline and use of occlusive dressing or the application of topical antibiotics/ antiseptics that are designed to remain in contact with the wound site.

Chronic wound infections have multiple bacterial contaminants amongst which Staphylococcus aureus is the most common. Bacteria produce a protective polysaccharide biofilm around themselves . This biofilm allows for exchange of water and nutrients and also impedes the entry of antibiotics. It may also be responsible for the increased resistance to the of antibiotics as well as to hosts natural defenses. Thus the biofilm prevents the wound bacteria from eradication

Bacterial colonization obstructs wound healing by impairing the white cell function, increasing tissue hypoxia and reducing the number and proliferation of fibroblasts through the various phases of wound healing.

INDIAN SCENARIO

The expenditure and time associated with wound care costitute a considerable problem in India. Evidence relevant to wound care in South India has been

published . Population surveys show that up to 21% of adults who are greater than 40 years of age have diabetes . Diabetic foot infections account for almost 10% of the total Indian hospital admissions. An Indian patient with a diabetic foot ulcer requiring surgical intervention will spend almost up to 32.3% of his/ her income on medical care. The amputation rate in India as a result of complications of diabetes is 8% to 9% above that in the developed countries. Given the increasing burden of diabetic and other wounds, the Indian patient will greatly benefit from these recent advances in wound care.

CONVENTIONAL TREATMENT METHODS

Standard treatment for all established wounds incorporates common principles employed in the management of all wound types. These include the removal of necrotic tissue through aggressive debridement that is achieved through debridement using sharp instruments, autolytic debridement by endogenous enzymes which are present in commercially available wound care products and proper moisture balance achieved through the selection of the proper wound dressing (28). For most of the chronic and acute wounds, saline-moistened cotton gauze has been the standard treatment of choice.

Therefore, wet-to-moist conventional gauze dressings require close maintenance and excess dedicated nursing time. Moreover, the removal of a wet-to-moist dressing that has been allowed to dry may infact injure the wound again by removing the just formed granulation tissue and thereby lead to delayed wound

healing. This procedure infact also causes considerable pain, impedes the healing process and increases the risk of infection.

Gauze dressings may appear much less expensive per dressing when compared to the modern synthetic dressings but the conspicuous increase in the labor costs and ancillary supplies such as gloves used and the biohazardous waste disposal substantially increase the total cost of conventional dressing.(43)

TOPICAL NEGATIVE PRESSURE WOUND THERAPY

NPWT is a novel technique for a managing an open wound by submitting the wound to either intermittent or continuous sub-atmospheric pressure (Morky was and Argenta 1997) Negative pressure is obtained by transferring away the gas molecules that are present in the wound away by using a suction pump.

With respect to the type of dressing used to fill the wound,there are at present two types of Negative Pressure Wound Therapy in practice.

I. FOAM BASED TECHNIQUE

II. CHARIKER-JETER TECHNIQUE

FOAM – BASED TECHNIQUE

Originally developed by Argenta and Morykwas in 1997 . The foam used is cut according to the shape of the wound and the foam is placed over the wound . The wound may be lined before applying the foam. There are two types of foam used.

I. GranuFoam - Black polyurethane foam which is available on Drug Tariff

II. Vers-Foam - White polyvinyl alcohol foam commonly used when there is a possibility of adhesion of the foam to the wound. Vers-Foam is not usually available on Drug Tariff.

The foam is secured over the wound and sealed in place using an adhesive film drape and a TRAC system. TRAC stands for Therapeutic Regulated Accurate Care systems . Plastic tubing is used to connect the dressing to the console that applies the suction force. V.A.C. systems are usually commenced under supervision in secondary care centres and the patient is then discharged with the suction console but the disposals like GranFoam dressing and canisters need to be provided to the patient.

POLYURETHANE(PU) OR POLYVINYLALACHOL (PVA) FOAM

PU foam is black and also very easily deformable whereas PVA foam is white and is stiffer and requires higher pressuresin order to deliver vacuum. Choice of the foam is totally dependant on the treating surgeon. The foam is covered airtight with

an adhesive drape through which a small hole is made and a TRAC (Therapeutic Regulated Accurate Care) pad applied over the hole. The adhesive dressing applied creates a completely sealed environment for moist healing of the wound and the TRAC pad is connected to the vacuum generator which acts as a source for suction and drainage. Pressures achieved at the TRAC pad-foam interface are constantly monitored by the VAC machine.

VERS FOAM

Vers-Foam dressing which is white in colour happens to be more dense and has a higher tensile strength. It is usually pre-moistened with sterile water. Due to its in adherent properties, it finds itself extremely useful in grafts in wounds and those associated with pain. It is generally recommended in sites where the growth of granulation tissue into the foam needs to be in a more controlled manner or the black foam is not tolerated due to pain. The minimal disadvantage is the necessity to maintain a higher levels of negative pressures of about 125mm Hg.

CHARIKER- JETER TECHNIQUE

It is a more recently developed NPWT systems.It utilizes flexible drains and gauze and are referred to as the Chariker-Jeter technique.

Moistened gauze is used to fill the wound before VAC application.. A silicone drain is inserted and sealed using an adhesive film drape. The silicone drain is attached to the suction console.

NEGATIVE PRESSURE WOUND THERAPY SYSTEMS

NPWT systems include a dressing set, drainage tubing, and a vacuum pump. The vacuum pump may be stationary or portable, work with AC or battery power. Recent devices not only allows for the regulation of the suction strength but also indicates the loss of suction with alarms. The dressing sets comprise of either foam or gauze dressing to be placed over the wound and an adhesive film drape to seal the wound airtight. There are a variety of configurations of draining tubes according to the wound being treated and the dressings available.

Redon bottles (high vacuum drainage bottles) were one of the early vacuum sources used for wound drainage and vacuum therapy (32) Initially the suction strength is approximately 900 mm Hg but declines as the canister is filled. The Redon set comes with a bottle and drainage tubing but no dressing set.

APPLICATION OF V.A.C

NPWT application is simple and can be down into three main steps.

First, a sponge must be selected or custom cut in order to fill the wound correctly. The sponge used most commonly is a black, reticulated polyurethane ether foam with pore sizes from 400 to 600 mm. Polyvinyl alcohol foam (White coloured foam, KCI), which has more dense reticulations, also is available. This variant is useful in situations in which a tougher sponge might be needed, such as tunneling. Sponges impregnated with silver (Granufoam Silver, KCI) are available as well for wounds with a high bacterial load. The sponge should be applied in such a way that it fills the wound precisely without overlapping onto normal skin, if possible. Although in some situations we have overlapped the sponge onto normal skin or "bridged" multiple wounds, the sponge can irritate normal skin. An alternative is to apply a protective dressing over the normal skin before creating a bridge.

The second important aspect of application relates to creating an airtight seal. Often, this is the most difficult element in applying the dressing. The seal is created by applying an adhesive occlusive dressing over the sponge and onto the surrounding skin. It is critical that the seal be able to withstand the negative pressure without leaking. This can be achieved by keeping the surrounding skin clean and dry. Liquid and aerosolized adhesives often are helpful.

The third element to NPWT is application of the vacuum. The vacuum tubing normally includes a disk placed at the end which helps to attach the tubing to the sponge thereby creating a good seal. The suction tube leads to a collection canister that is in turn attached to an adjustable vacuum pump. Usually, continuous 75 to 125 mm Hg vacuum is used for all wound types. When the white Foam is placed, 125 to 175mm Hg are used. Although intermittent vacuum therapy have reports of improved vasculaity than continuous , it often is not tolerated well by the patient. It generally is recommended that the dressing is to be changed every second or third day. At the time of foam change, other traditional wound-healing modalities may be used (eg, pulse lavage). Although the initial application of negative pressure therapy was an inpatient endeavor only, it is now used routinely on an outpatient basis, allowing for greater flexibility in dealing with chronic wounds that otherwise do not require hospitalization.

Once the NPWT dressing is applied, it offers a stable environment for the wound to heal. The shear stresses that normally affect the healing of the wound cannot damage the fragile newly formed tissue as NPWT keeps the patient mobile.The patients comfort levels are highly increased as the bulky and offensive smelling dressings need not be tolerated with,with NPWT. With the 48 hourly interval period,the nursing input is also drastically reduced.

Most clinicians maintain a sub-atmospheric pressure of about 125 mm Hg using PU (black) foam. Evidence for this pressure being the optimum is limited.

Morky demonstrated a bell shaped distribution between the increase in pressure with the local tissue perfusion in a swine with an acute wound. Morky showed that there was a conspicuous drop off in tissue perfusion after a time period of five to seven minutes of continuous vacuum.

A comparative study of the rates of granulation tissue formation in the healing wound under different pressure cycles of NPWT showed vividly that intermittent treatment demonstrated faster rate of granulation tissue formation as compared to continuous treatment.. These results have however only been demonstrated so far in acute animal wounds and as yet have not been shown in human wounds. But,so far in clinical practice many patients find the intermittent treatment difficult to tolerate due to the discomfort during the changes in pressure.Therefore the continuous regimen is more commonly used nowadays.

The NPWT dressings are normally changed in a time period of about 48-56 hours . In certain exceptional circumstances like over a skin graft,they are changed at a much longer duration.It is highly recommended that dressings need to be changed even more frequently in the presence of aerobic infection. In situations where the dressings are allowed to stay for longer periods of time(>56 hours),the granulation tissue tends to grow into the foam making it uncomfortable. Anecdotally the granulation tissue thus formed is also found to be less healthier ,the longer the dressing is left in place.

However, theCochrane report reviewed a number of studies and finally concluded that with the current literature, it is still not possible to determine the optimum NPWT regimen.

PHYSIOLOGICAL BASIS OF VAC

The VAC device consists of a highly porous polyurethane sponge with spatial connections between the pores, allowing subatmospheric pressure applied to the sponge to be distributed equally throughout the sponge. The VAC device used today applies a 70- to 150-mmHg vacuum.

The VAC is modeled as a series of pores with the polyurethane sponge in contact with the wound. We assume the pores to be symmetric and that there is no lateral displacement in the center of the pore. Furthermore, where the wound contacts the sponge, we expect no vertical displacement. These *boundary conditions* and pressure are applied in a two-dimensional finite element model.

The wound is modeled as a *linear*, homogeneous, isotropic, *elastic* material. Although a nonlinear stress-strain relationship exists for the skin and other connective tissues, the skin shows a fairly linear stress-strain curve in the observed strain

ranges.[15] Furthermore, we varied the compressibility of the material (*Poisson's ratio*) to study this effect on wounds.

Five parameters were studied: stiffness of the wound (*Young's modulus of elasticity*); compressibility of the wound (Poisson's ratio); pore diameter of the sponge, defined by the distance between two struts in the model; pore volume fraction of the sponge; and pressure applied to the sponge (or differential thereof). We modeled variation in each of the above parameters . As each parameter was sequentially varied, all other parameters were assigned "standard" values usually observed in the application of the VAC

VAC-treated wounds show a marked increase in undulating contour with protrusions and indentations cor-responding to the geometry of the sponge's contact with the wound . Areas under-neath an occlusive dressing only, without sponge contact, do not undulate . These induced surface irregularities cause an increase in microscopic surface area, and thus local mechanical distention of tissue, without increasing the actual size of the wound. Mea-surements of the surface length of a histologic cross-section of a wound demonstrate an in-crease in surface length of 22 percent over 4 days compared with wounds not treated with the sponge. In addition, a rich vascular net-work was noted to be present in the wounds treated with the VAC sponge compared with control sites

Finite element analysis of the wound-VAC system was conducted to directly predict the *strain* imposed by the VAC sponge on wound tissue. Visible in the finite element analysis is tissue stiffness (characterized by Young's mod-ulus), tissue compressibility (characterized by Poisson's ratio), sponge pore diameter, pore volume fraction, and variability of wound tissue strain over a range of imposed pressure . Higher strains can be induced by increasing pressure, increasing pore diameter, or decreas-ing strut thickness. Strains are also predicted to be greater when mechanical properties of the wound such as the Young's modulus or Pois-son's ratio are decreased.

Using physiologic values for tissue,[15,16] typical sponge pore diameter, and pressures used clin-ically results in a striking resemblance between the finite element analysis output and the his-tologic cross-section . Point-wise strain

along the simulated wound surface was maxi-mal in the regions close to the struts and, consistent with a model of a thin membrane acted on by a uniform pressure, nearly con-stant across the majority of the wound tissue.

Strain Variability along the Wound Surface

Surface strain varies in a repeating pattern across the wound tissue. Strain is negative (compression) immediately underneath the sponge struts, as they indent the surface of the wound. At an applied pressure of 15 kPa (110 mmHg) typical of the VAC, the tissue quickly reaches a peak strain of 125 percent immedi-ately adjacent to the struts (0.15 mm), as the forces of strut compression and vacuum suc-tion oppose each other maximally and most directly at the edges of the sponge pores. The bulk of the wound tissue within the sponge pore, however, experiences lower strains (5 to 20 percent), with tissue at the center of the sponge pore experiencing the lowest strains (up to 5 percent) . These strains are dependent on wound thickness. At a wound thickness of 1 mm, the center strains were 0.67 percent, whereas for the most superficial wounds (0.5 mm), the center strains were 5.1 percent.

Wound Healing Affects Tissue Strain

During wound healing, tissue elasticity and compressibility change,[15] and wound displace-ments induced by the VAC, even at constant pressures, are likely highly time-dependent. As wounds heal, they tend to become fibrotic with increasing

stiffness (Young’s modulus of elas-ticity), thereby decreasing average wound strain. For example, increasing the stiffness from 50 kPa to 70 kPa would lower the average wound surface strain from 35 percent to 12 percent, with a concomitant decrease in peak strains from 200 percent to 125 percent .

As tissue becomes fibrotic or edematous, the Poisson’s ratio may increase, further decreas-ing the average and peak surface strains. In the simulation, raising Poisson’s ratio from 0.36 to 0.50 (incompressible tissue) resulted in the de-crease of average surface strains from 26 per-cent to 22 percent . In the ranges studied, surface strains also appear to be far more sensitive to changes in tissue stiffness than tissue compressibility. Our model shows that raising tissue stiffness by 40 percent causes a nearly 66 percent decrease in the surface strain, whereas an equivalent change in com-pressibility results in only a 15 percent de-crease. This suggests that changes in the stiff-ness of the wound over time may be an important factor to consider when optimizing therapies for healing wounds.

Applied Strains Are Device-Dependent

It has been suggested that cells can be in-duced to respond to growth factors and prolif-erate when undergoing an optimal degree of strain.[17–20] To examine how changes in VAC device properties can be harnessed to produce optimal wound tissue strain, finite element

analysis models of the VAC were constructed with varying pore diameter, strut thicknesses, and imposed pressures.

Strain is very sensitive to changes in pressure. Doubling applied pressure from 10 kPa to 20 kPa also doubles average surface strain , but doubling average pore diameter from 0.8 mm to 1.6 mm results in only a 50 percent increase in surface strain . In addition, decreasing the thickness of the sponge struts causes a decrease in the av-erage surface strain . Considered together, these results suggest an exquisite sen-sitivity of the imposed strain to VAC device properties and demonstrate a broad dynamic range of achievable strains in the wound tissue achieved by varying device parameters

PROTOCOLS FOR USE

Protocols for use of NPW therapy has to be tailored specifically to requirements of each individual patient. Therefore if the objective of the treatment is to fill a cavity wound with granulation tissue then regular dressing changes at two day intervals are suggested. Whereas ifthe objective is to bold a skin graft in place then the dressing is left in situ at a lower pressure approximately 75mm Hg for five days.

The reconstructive requirements of the wound may be brought down the reconstructive ladder with the help of NPW therapy. A wound expected to require a flap reconstruction can be efficiently reduced in size,thereby producing a healthy wound bed that can be closed with a skin graft which is a much more simple procedure as compared to flap reconstruction.

Some of the practical difficulties faced while changing the dressings at 48 hourly intervals are the dressings getting adherent to the wound bed. This issue can be handled by application of saline or lignocaine to the points of adhesion between the wound and dressing.

NPW therapy should also be terminated once it is found out that the foam and adhesive layer are not effective in absorbing the exudates. This would finally end in a macerated and engorged wound. Treatment should be terminated either if the

objectives of wound therapy have been reached or if infection or a lack of progress is noted.

TECHNICAL ASPECT

The most commonly used dressings in NPWT are foam and moistened cotton gauze.

Vacuum Assisted Closure advocates open-celled reticulated foam dressing in order to evenly distribute the negative pressure all across the wound surface.A transparent film is then used to cover the wound which prevents bacteria from reaching it and also seals the wound thereby creating a vacuum. Foams that contain silver or other antibiotics are also being used nowadays..

Moistened gauze can also be employed instead of foam inorder to cover the wound surface.Non adherent moistened gauze is gently placed over the wound bed and is covered by a adhesive film dressing. An antimicrobial gauze can also be used instead.

A plastic tubing is then connected to the dressing(foam or gauze) which leads into a canister and from there into a suction device. The constant suction,as previously mentioned removes the excess exudates into the canister.The pressure set in the vacuum device can be altered according to the wound type ranging from about -5 to -125mmHg .This can also be adjustable to higher pressures, depending on the device used(41)

PRACTICAL TIPS

The VAC dressing can also be used in patients with multiple wounds. After applying the VAC in a airtight manner to the main wound,the tubing is allowed to pass through the other wounds the patients has and appropriate incisions are made over the tubing upon the smaller wounds and airtight dressings are applied over them also thereby providing a negative pressure environment in the smaller wounds also.

The problem of obtaining an airtight seal in hair-bearing areas can be solved by laying the occlusive VAC film into hydrocolloid dressings that seem to adhere more strongly to these areas.

Another practical aspect is to practice putting some lignocaine into tube thereby reducing pain while removing the dressing.

Applying Compound Benzoin Tincture to the surrounding skin, letting it dry and there after applying the adhesive dressing also helps in giving it a better adhesion.

MECHANISM OF ACTION

Increased blood flow to the wound bed via enhancement of capillary blood flow [56]

Increased new blood vessel formation with profuse granulation tissue

Increased number of active fibroblasts and macrophages

Enhanced epithelial cell migration

Decreased bioburden, bacterial toxins, and subsequent cessation of delay in the healing process

Decreased harmful wound fluid and toxic products at the wound site

Decompressed excess interstitial fluid with subsequent decreased microvascular occlusion , inelasticity and periwound induration.

Reduction in the number of dressing changes thereby decreased damage to delicate new tissue

Provision of a , normothermic wound environment that allows efficient epithelization and synthesis of growth factors needed for wound healing

Provision of healing by primary intention by mechanical approximation of wound edges

Promotion of viscoelastic flow and distraction histogenesis due to stretching of tissues and persistent stimulation of the cytoskeleton that causes subsequent enhanced mitosis

Decreased shear forces at the graft site during the stage of inosculation via uniform wound bed immobilization

Decreased seroma/hematoma of grafts and flaps

Limitation of zone of injury after acute orthopedic trauma

Splinting effect (sternal, abdominal).

Blood flow analysis was performed in the initial laboratory publication by Morky was and colleagues [4], who reported that using laser Doppler needle probes, increased blood flow was noted in the subcutaneous tissue adjacent to wounds created in pigs when the sub atmospheric pressure was applied. In this study, blood flow increased to a peak that occurred at 125 mm Hg suction (Fig. 1). At greater than 400 mm Hg suction, flow began to decline below baseline. Other investigators also demonstrated improved blood flow in different circumstances, including uninjured forearms and burn injuries, when tissue was exposed to topical negative pressure [5-7].

The formation of granulation tissue under a negative pressure environment also has been studied. It was noticed early on that granulation tissue formation

seemed more rapid and robust with NPWT [3]. In Morky was and colleagues' [4] swine study, they demonstrated this-showing that in comparison with controls there was a statistically significant increase in granulation tissue formation when measured by wound volume. Another study in a rabbit model also demonstrated increased granulation tissue formation using a lens micrometer [8]. The mechanism for this improvement is undetermined, but it may be related to changes in wound-healing pathway signals.

Another proposed mechanism of benefit is reduced bacterial bio burden in the wound. Bacterial clearance was evaluated by punch biopsies in a swine model that demonstrated decreased organism counts by day 5 of therapy (Fig. 2) [4]. Decreased bacterial counts also have been demonstrated in human studies [9], although this has not been accepted universally [10].

In theory, by evacuating exudate from the wound surface and keeping the wound sealed from outside contamination, the bacterial load should be reduced or at least kept from accumulating into and infection.

Another interesting area of inquiry has been the effect of cell membrane stress in a healing wound. Laboratory studies demonstrated that shear stress on cell membranes can induce second messenger pathways that play an important role in wound healing. Chen and colleagues [11]showed that the vascular endothelial cell growth factor (VEGF) pathway was stimulated, even though VEGF was not present in the wound fluid. Studies of dermal fibroblasts also have shown up-regulation of a

variety of kinases involved in wound-healing pathways in response to deformation [12]. This suggests that shear stress may have an independent effect on wound-healing pathways. It has been postulated that the negative pressure conveyed through the sponge dressing stimulated this shear stress event in wounds, leading to activation of these pathways. How these pathways relate to wound healing rates it unknown, but ultimately may be one of the critical elements in understanding why NPWT is successful. Willy, in his book on vacuum therapy, published in 2006, (32) mentions five mechanisms by which NPWT helps in the process of wound healing: Retraction of wound, stimulation of granulation tissue formation, constant wound cleansing after adequate primary surgical debridement, continuous removal of exudate, and reduction of interstitial edema.

ISSUE OF DEFINING THE APPROPRIATE NEGATIVE PRESSURE

For almost over half a century from now,the consequences of exposing wounds to negative pressure is being studied in detail but still there is no clear evidence stating the adequate pressure intensity, prescribed duration of treatment, and interval needed between treatments to provide the most efficient therapy. In 1997, Morky et al [57] clearly showed that microvascular blood flow to a wound site increases 4 times the baseline values with sub atmospheric pressures of 125 mmHg, while the blood flow was inhibited at negative pressures greater than or equal to 400 mmHg.

Based on this result of Morky, sub atmospheric pressure of 125 mmHg became the most common pressure setting while using this technique. However, previous to

that research, Russian physicians were refining NPWT. In 1987, Usupov and Yepifanov [58] used a rabbit model and concluded that in order to avoid any tissue damage, pressures in the active drainage systems must not exceed – 80mmHg and that lower pressures were less likely to cause postoperative hemorrhage. The same study also demonstrated occurring of new tissue hemorrhage of previously coagulated vessels with pressures that measured less than – 120 mmHg to – 125 mmHg.

Aside from inconsistencies in pressure levels that were noted between Morky was et al and the Russians ,there were also conspicious differences in pressure intervals between them both. Morky was et al stated that optimal results were obtained when VAC was applied continuously for the first 48 hours followed by the intermittent regimen (5 minutes on and 2 minutes off) [57].

In 1986, the Russian researchers then published a study that revealed that negative pressure wound therapy could be successful when applied twice daily for a period of 2.5 to 3 hours. [58] The disparity in findings between both underscored the need to define the pressure intensity parameters, prescribed duration of treatment, appropriate interval between treatments, suggested mode of application, and probable timing of application to provide the most efficient and cost effective therapy.

In 2004, Wacken fors et al [59]from Sweden conducted a study which was published in which inguinal wounds in pigs were observed subjecting them to

pressures ranging from 50 to 200mm Hg and the microvascular blood flow was observed .Laser Doppler was then used to measure the blood flow in which the sum of all erythrocytic motion was quantified in a volume of 1mm, there by providing a platform to reliably perform measurements in small, closely spaced skin areas.[60]

The findings of this study was then correlated to predict how NPWT affects microvascular blood flow with specific consideration of tissue type and the distance of blood flow from the edge of the wound , parameters that were not focussed in to the work done by Morky was et al. The results of the study found out that NPWT induced a conspicious increase in micro vascular blood flow upto a few centimeters away from the wound edge, which might accelerate formation of granulation tissue and the process of wound healing [59].

Conversely, nearer to the edge of the wound, negative pressure resulted in hypoperfusion that increases along with increasing subatmospheric pressure with the possible result of ischemic tissue damage. Furthermore,the type of tissue is also a predominant factor : the increase in perfusion occurred closer to the wound edge in muscle as compared to subcutaneous tissue (1.5 cms as to 3 cms at negative pressures of 75 mmHg).

Wackenfors and her team later proposed that a proper decision is to be made when selecting the amount of sub-atmospheric pressure for NPWT treatments. The vacuum should be adequately robust enough to drain the wounds and arrest superficial bleeding. At the same time, the vacuum should not create a significant

ischemic zone impeding the healing of the wound. Based on the findings, the investigators finally concluded that when treating stiff muscular tissue , a negative pressure of approximately 10mmHg may be reasonable, thereby limiting the extent of the zone of hypoperfusion to 1 cm from the edge of the wound. When treating softer tissue like fat and subcutaneous tissue, which is more vulnerable to hypoperfusion, the application of a even lower negative pressure, equal to 75 mmHg, may be beneficial. Although such pressure recommendations are uncommon among NPWT practices, the Russian literature authorises the use of these pressures during treatment.

CLINICAL USES

ACUTE WOUNDS

Acute wounds often are ideal candidates for NPWT. In a wound that cannot be closed primarily because of infection or swelling. NPWT can enhance the time to wound closure. Often, such wounds have a significant amount of edema and fluid loss that is managed effectively with this system. In addition, wounds that previously might have required prolonged periods of dressing changes or skin grafts sometimes can be converted to delayed primary closure with the use of negative pressure therapy.

Nonviable tissue should be debrided before the initiation of therapy. Foreign bodies should be extracted and complete hemostasis obtained. Vital structures that

are exposed such as major vessels, viscera, and nerves, should be covered by mobilizing the local muscle or soft tissue, if possible. In the setting of significant contamination , dressings are to be changed with repeat debridement as necessary. Management of acute wounds using NPWT has allowed successful healing and primary closure of wounds from war trauma in Iraq with low infection rates[13].

CHRONIC WOUNDS

Chronic wounds are wounds that fail to heal in the normal healing phases of inflammation, proliferation, and maturation. They represent a heterogeneous group of wounds of multiple cause and conditions, such as pressure ulcers, diabetic ulcers, venous stasis ulcers, vasculitic ulcers, and chronic non healing wounds resulting from trauma or dehisced surgical wounds. The use of NPWT has profoundly changed the management of these patients, who often are poor surgical candidate and have failed previous operations. Such wounds often area burden to caregivers, because of the multiple frequent dressing changes, and are incapacitating to the patient.

Chronic wounds often exhibit progressive edema, compromise of perfusion, and elevated levels of proteolytic enzymes and cytokines that inhibit granulation tissue formation and epithelialization. The fluid that is drawn from the wound by the NPWT system is rich in cytokines, acute –phase proteins, and proteolytic enzymes, suggesting that inhibiting factors are removed from the wound. The removal of interstitial fluid and inhibitory cytokines leads to a less favorable environment for bacteria and wound behavior, which becomes more like an acute wound.

Thus, NPWT has proven useful in managing such wounds and allows for easier wound care, particularly for wounds that are difficult to dress and lose significant amounts of fluid. Wounds that have been stagnant for weeks, months, and in some cases, years, usually demonstrate a return to the normal healing progression and, ultimately, to a healed state [14-16]. Diabetic foot wounds have demonstrated a particular benefit, with one recent multicenter, randomized, controlled trial showing a statistically significant improvement in wound healing time [17].

EXPOSED BONE OR TENDON

Wounds in which there is exposed bone, tendon, or other hardware have been treated successfully with negative pressure therapy. For wounds with exposed bone and intact periosteum, NPWT promotes granulation tissue – either bridging the time for definitive wound closure or enabling a more simple surgical option (e.g., split-thickness skin grafting).

In orthopedic trauma, the use of NPWT has allowed for primary closure with a high rate of success and is becoming a primary mode of treatment for open fracture sites [18-20]. NPWT also has been useful in dealing with bone without periosteum, such as following a scalp resection for turn or. The exposed calvarium can be burred down until punctuate bleeding is noted from the diploic space.

NPWT assists in promoting granulation tissue formation in such wounds, ultimately leading to skin grafting. It also is possible to perform the skin grafting immediately after burring the outer table of skull in a single – stage approach [21].

Exposed tendon also has been treated with negative pressure therapy[22]. If the tendon is healthy with viable paratenon, the NPWT promotes early granulation of such wounds. A nonadherent dressing beneath the foam may minimize desiccation and trauma to the tendon. NPWT often promotes granulation tissue completely covering the tendon, enabling simple techniques (eg., skin graft) rather than formal flap closure.

If there is exposed hardware in the wound, it may be possible to salvage this with NPWT [20]. Enough healthy granulation usually can be induced from the surrounding tissue to enable secondary wound closure or flap coverage, without the need to remove the hardware. The amount of exposed hardware that can be salvaged in this fashion is variable, but usually is only a few centimeters. The quality of the surrounding tissue and overall status of the patient must be considered. In dealing with exposed hardware, sound surgical priniciples should be followed. In the setting of large areas of hardware exposure or infection, the hardware needs to be removed and alternative fixation established.

OPEN ABDOMEN

After a damage-control laparotomy, such as in severe trauma, ruptured abdominal aortic ancurysm, or peritonitis, the abdomen often must be left open because it may be too difficult or too dangerous to close. NPWT has proven to be a useful adjunct in managing the open abdominal wound. When the wound is to the fascial level, NPWT is applied as with any soft tissue wound. In the setting of fascial dehiscence, care must be taken to ensure that the underlying viscera are protected. In multiple studies, NPWT proved useful as a means of wound management in patients who had abdominal compartment syndrome, because of its ability to create a neoabdominal wall and handle the egress of fluid, ultimately allowing for late fascial closure in some cases. More importantly , early fascial closure may confer a survival benefit [23-26].

A nonstick dressing should be placed over the bowel to act as an interface between bowel and the overlying sponge. This dressing should be fenestrated to allow peritoneal fluid to pass into the sponge. NPWT helps to reduce intra-abdominal fluid and bowel edema while aiding skin and fascial approximation. As in other situations, the dressing should be changed once in 2 to 3 days. This usually can usually be performed in the intensive care setting with proper sedation.

If necessary, the patient can have repeat exploration of the abdomen without difficulty. As bowel edema resolves and the defect narrows, the suction helps to pull the fascial edges together. In some cases, open abdominal wounds can undergo

fascial closure, even after weeks of open treatment [24]. If the wound cannot be closed secondarily, there usually are sufficient granulation tissues on the bowel to enable skin grafting.

STERNAL WOUNDS

Following cardiac surgery, patients can develop a median sternotomy wound infection and dehiscence. Such wounds are difficult to manage and can Icad to increased morbidity and mortality, especially when there is exposure of the mediastinal contends. NPWT has become a common modality as cardiac surgeons have accepted its usefulness in managing these wounds [27,28]. The dressing is applied in a similar fashion to other wounds, but particular attention should be paid to protection of underlying structures. If necessary, a nonstick barrier should be placed between the sponge and the mediastinum. Cases of right ventricular rupture and leakage of fresh vascular grafts have been reported[29].

The sponge collapses when suction is applied, pulling the edges of the sternum toward the midline. The effect is stabilization of the chest wall, which, in turn, provides better respiratory mechanics and less discomfort for the patient [30,31]. Surgical debridement should be performed as normally indicated. Once the wound is clean, definitive closure of the sternum or defect can be accomplished using standard surgical techniques or allowed to close over time with dressing changes. Using these techniques, fewer flaps were needed for wound closure, and survival rates with mediastinitis were improved [32,33]. Care must be taken to protect the

underlying mediastinal structures by interposing a nonstick barrier, such as petroleum gauze, between the sponge and the wound.

FASCIOTOMY SITES/EXTRAVASATION INJURIES

Fasciotomy wounds are ideally suited for management with NPWT . Edematous muscle and tissue can be decompressed more rapidly, thus shortening the interval between fasciotomy and wound closure. In most instances, the fasciotomy wound can be closed secondarily, rather than requiring a skin graft for wound coverage [34].

Another benefit may be related to the ability of NPWT to remove unwanted by-products of tissue injury. The fluid removed from such wounds is believed to be rich imunoglobin, and it has been speculated that the removal of this fluid by an NPWT system also results in faster serum clearance. Although human studies are still in progress, this effect has been demonstrated in a rabbit model [35].

Based on the knowledge that local and systemic toxins could be evacuated from a wound using the NPWT, laboratory tests were performed to examine its role in extrinsic toxic substances. Early application of the NPWT to a site of doxorubicin injection in a pig model prevented ulcer formation [36]. In humans, several case reports have examined the successful use of NPWT in the setting of toxic bites or extravasation injury [37-39].

SKIN GRAFTS/ARTIFICIAL SKIN

NPWT has proven to be a useful tool in skin-grafting procedures. By assisting in creating a more vascular and cleaner wound bed, it can augment the percentage take of a subsequent skin graft. In some cases, vacuum sponge dressings have allowed skin grafts to be performed in areas that originally had sparse granulation tissue or exposed bone or tendon.

The skin graft is bolstered to the wound bed by the sponge, which conforms to the wound shape and helps to eliminate any dead space and reduce shear forces . The skin graft is protected from adhering to the sponge by a nonstick dressing (dashed line).

In addition, the vacuum-sealed sponge serves as an excellent fixation device for skin grafts. The skin graft is harvested, fenestrated, and placed on the wound bed in the usual fashion. A single layer of a permeable nonadherent dressing , like Adaptec or Xeroform, is placed between the skin graft and the dressing sponge. As air is evacuated from the sponge, it traps the skin graft between the sponge and the underlying tissue. Also, it conforms to the wound bed, thereby acting as natural splint to hold the graft against the wound. This firm approximation of the graft, along with the edema-and bacterial-reducing property of the negative pressure system, is believed to help reduce failure due to shear forces, fluid collection, and infection.

Several studies examined the usefulness of this technique and found that it facilitates skin grafting and may increase the take rate [40-42].

This same principle has been applied to artificial dermis, such as Integra and other skin substitute products. NPWT increased take rates and decreased the time required for vascularization. Traditionally, Integra is not ready for a secondary skin graft for 2 to 3 weeks ; however, when managed with NPWT, secondary skin graft often can be applied in 1 week, with a 93% skin graft take [43].

BURNS

The application of NPWT in acute burns also has been studied, with particular attention paid to the zones of injury . The central portion of injury , or zone of coagulation, has undergone irreversible damage. Surrounding this is the zone of stasis (or zone of injury). The zone of stasis is believed to be a critical part of the burn wound, because this area may or may not progress to coagulation and permanent tissue loss. The effect of NPWT on the zones of injury was examined in a swine model. The vacuum dressing decreased burn wound progression, thus preserving more of the zone of stasis tissue [44].

In humans, NPWT was useful in preparing for skin grafting and may decrease the progression of injury. Burned hands treated with NPWT had a more rapid reduction in edema, with improved physical therapy and hand mobility. In

addition, the sponge allows for a clean method of dressing the burns while functioning as a splint to hold the hand in the desired position [45-47].

CLOSED WOUNDS

Recently, experience was reported using the vacuum-sealed sponge as a dressing over a fresh wound closure [48]. Because NPWT is useful in reducing edema in open wounds, it was proposed that this same property would be useful for closed incisions. In situations in which edema is expected to be a significant problem, such as flaps in dependent areas or incisons in obese patients or edematous tissues, this may provide some benefit by improving incisional integrity and reducing wound infection. In our experience, it can be applied over a fresh flap and does not appear to result in any compromise to the underlying flap. In fact, it is possible that the negative pressure actually facilitates blood flow into the distal aspects of the flap.

PEDIATRICS

NPWT is applicable to pediatric conditions similar to those in adults. Some children may not tolerate the dressing changes and may require anesthesia assistance. This can make outpatient therapy difficult. In an inpatient setting, NPWT can be used to limit dressing changes to every third day, which may make complex wound care more tolerable.

As in adult patients, NPWT aids in the recovery time and may reduce the need for more extensive operations [49, 50]. Because children often have difficulty

understanding and complying with wound care, NPWT can simplify dressing and facilitate procedures, such as skin grafting, that otherwise would be difficult because of size or location (Fig. 10).

SALVAGE PROCEDURES

NPWT can also be extremely helpful salvage of difficult cases. This wound management technique can be applied as a "last resort" or even as a standby procedure until the patient becomes healthy enough to cope up with surgery. Wounds that need salvage procedures are necrotizing fasciitis involving large areas of skin loss,abdominal dehiscence. These wounds can be disturbingly large with unhealthy wound beds. The patients also happen to be unsuitable candidates for immediate major reconstructive surgery that requires a good cardiovascular status. . Use of negative pressure therapy in situations like these may significantly lower the reconstructive requirements of the wound.

ADJUNCT TO SURGERY

An ideal method to maintain skin grafts upon a suitable wound bed requires firm fixation on wound, avoiding shearing forces, adaptation to concave or convex surfaces, evacuation of sub-graft seroma and haematoma and most important of all, minimization of infection. Splintage of graft using NPWT fulfils most of these criteria and various studies have shown take rates of over 90%

.

CONTRAINDICATIONS AND COMPLICATIONS

Wounds should be cleaned and thoroughly debrided before sponge placing. Some fibrinous material and thin exudates can be managed, but thick exudates, necrotic material, and pus will clog the sponge. The sponge should not be placed over any exposed major vascular structures, and the visceral organs must be protected. The sponge can adhere to these and cause tearing of the outer layers; significant bleeding or exsanguination has been reported [51,52].

If there is exposed vasculature or major organs, a petroleum-impregnated gauze should be interposed between the vital structure and sponge. The suction should be regulated properly. The VAC system supplied by KCI eliminates the possibility of inadvertently applying excessive suction to the wound, as has been reported with the use of wall suction.

When the sponge is kept in place for greater than 3 days, there begins to be some amount of ingrowth of tissue into the sponge applied over it. This often causes trauma while removing the dressing and a high possibility that fragments of the sponge will remain back in the wound . There have also been occasional reports of Toxic Shock Syndrome(TSS) [53].

NPWT do not lend a helping hand in treating grossly infected wounds. It needs to be surgically debrided,topical desloughing agents like Purilon gel may also be used. NPWT therapy is also not recommended for use in actively bleeding

wounds, malignancy, over exposed vessels.. The presence of abnormal coagulation, fistulous connections, exposed body cavities, or following oncological resections has to be taken into consideration and clinical judgement made assessing the risk to benefit ratio.

Contraindications to NPWT for chronic wounds include :

a. Exposed vital organs

b. Inadequately debrided wounds with gross contamination.

c. Untreated osteomyelitis

d. Presence of untreated coagulopathy

e. Necrotic tissue with eschar

f. Malignancy in the wound (negative pressure therapy may lead to cellular proliferation)

g. Allergy to any component employed in the procedure.

NPWT should be used with extreme caution when there is active bleeding ,patients who are on anticoagulants, difficult wound hemostasis, or when the dressing is in close proximity to any blood vessels.

If there is any exposed vessel or major vital organ, a petroleum impregnated gauze must be interposed between the vital structure and sponge and care should be taken to regulate the suction properly..

WOUND DRESSINGS

Dressings generally are selected based on the characteristic features of the wound at any given point during the process of healing. (28) Exudative wounds will need an absorptive dressing (hydrocolloid, foam, alginate, hydrofiber) whereas dry wounds might need a dressing that provides adequate hydration (hydrogel). The type of dressings will change periodically as the wound progresses through various stages of wound healing. Synthetic wound dressings effectively maintain a moist environment by inhibiting the loss of water vapor from the wound. Moist wound environments aids in the process of epithelialization and healing.

FUNCTIONS OF IDEAL SYNTHETIC DRESSING :-

- It removes excess exudate and toxic components;
- Should permit gaseous exchange;
- Should provide thermal insulation;
- Should protect against secondary infection.

Synthetic wound dressings are available in a wide variety.(44-46) Some of the unique features of each are described subsequently. These dressings are often used in conjunction with silver or other topical agents that are intended to limit infection and speed healing. The following dressings may be used on acute or chronic wounds depending on the nature of the wound.

HYDROCOLLOID DRESSING

These are composed of adhesive, absorbant, and elastomeric components. Carboxymethycellulose is the commonest absorptive ingredient. They are not permeable to water but permeable to moisture . In addition, they also facilitate autolytic debridement, they are self – adhesive,they mould well, provide light to moderate absorption of exudates and can be left in place for many days,hence minimizing skin trauma and disruption of healing. They are highly beneficial for light to moderately exuding, acute or chronic partial – or full – thickness wounds, but they are not useful on infected wounds. The hydrocolloid forms a gel on prolonged contact with the wound fluid.

FOAM DRESSINGS

The composition of foam dressings vary widely. They usually consist of a polymer, often polyurethane. These have small, open cells that holds fluids. Some of the forms of foam dressings have a covering the top surface that is waterproof .It may or may not have any adhesive coating on the border or the wound contact side. The foams easily permeate water and gas.They also absorb light compared to heavy

exudates.Patients with venous leg ulcers with compression dressings usually benefit with such dressings.

FILM DRESSING

This is a single thin sheet of polyurethane that is transparent and coated with an adhesive on one side.It allows free passage of gases and moisture but does not let in any wound fluids. Film dressings are impermeable to bacteria , retain moisture, thereby allowing observation of the wound , and do not necessiate a secondary dressing. The adhesive is inactivated by moisture and therefore will not stick to the moist wound bed or to moist skin. Excessive fluid buildup may break the adhesive seal and lead to leakage. Film dressings are beneficial for superficial wounds with minimal exudates.They are commonly used to attach a primary absorbent dressing,in a way as a secondary dressing. The dressing remains in place for about seven days if significant amount of fluid does not collect.It is hard to apply a film dressing due to self – sticking.It must be placed beyond the wound edges by at least 1-2cm.The split skin graft donor site is ideally dressed with film dressings.

ALGINATE DRESSINGS

Calcium or calcium – sodium salts of natural polysaccharides that are obtained from brown seaweed forms the major source for alginate dressings. The alginate forms a hydrophilic gel when it comes into contact with sodium rich wound fluid as a result of ion exchange. This hydrophilic gel can absorb upto 20 times its weight and the rate of re-injury is averted by its property of not adhering to the wound. In heavily

exuding wounds,where there remains constant exudates to prevent its drying,the dressing can be kept in place for more than 7 days.

Film dressings supplement the alginate dressing holding them from drying out and holding them in place.

HYDROFIBER DRESSING

The characteristic feature of hydrofiber dressing is the presence of sodium carboxymethylcellulose fibers(47) in them that help in maintaining a moist wound environment by absorbing large amount of exudates thereby a gel is formed.

Specifically useful in highly exuding wounds.

HYDROGEL SHEETS

These are made of cross linked polymers arranged in a three-dimensional framework.Since they have a high water content,they provide moisture to the wound.But depending upon their composition they can also absorb a significant amount of fluid.They have the following advantages as a Negative Pressure Wound Therapy device:

- Adequate hydration of the dry wound beds
- Provide a soothing and cooling feel and hence reduces pain
- Simple in application and removal

These do have some disadvantages like :

Wounds may require frequent dressing change,every 1-3 days

These are not effective in wound with heavy exudates

A variant,Amorphous hydrogel, is similar in as aspects except for the cross linking.These have the advantage that they provide moisture to a dry wound and also causes autolysis of necrotic material by forming an eschar.Other ingrediants that the gel may contain are collagens,alginate,complex carbohydrates,etc.In shallow dressings,another dressing a second cover may be useful.

COLLAGEN-BASED DRESSINGS

Collagen plays a pivotal role in all aspects of wound healing,unlike previous concepts that they provide only the structural support within a wound.When a wound is formed,the collagen gets exposed and platelets aggregate around this exposed collagen.These platelets now produce growth foctors and cytokines that attracts all the inflammatory cells.The collagen and other protein debris in the wound gets degraded thus producing factors that attract fibroblasts.These fibroblasts start producing matrix metalloproteinase along with collagen which in turn produces factors attracting more fibroblasts,vascular endothelial cells and also epithelial cells.These together form the granulation tissue.The non-viable collagen is degraded by the MMPs.Sometimes when too much of MMPs are produced,they destroy the normal collagen too and this occurs in chronic wounds.Collagen based dressings

basically act by stimulating the fibroblasts.These contain purified collagen that are obtained from porcine,bovine or avian sources.

Infected wound are defined as those having a bacterial count of 10^5 colony forming units per gram of tissue.The bacteria need not always invade the tissue,most wounds are either contaminated or colonized by them.The concept of 'critical colonisation' was put forward to emphasize that bacterial growth can delay wound healing even in the absence of infection.This requires gentle irrigation with normal saline or occlusive dressings or antiseptics.

SKIN GRAFTS

Skin grafts are mainly used in the management of venous leg ulcers(56),burns wound and diabetic foot ulcers.(57)

Skin grafts are proposed to assist wound healing.They provide dermal collagen, growth factors and a biological occlusion that protects the wound. (57, 58)

Skin grafts can be autograft,that is from the same individual,or allograft,that is from another human being.

Skin grafts are used only when the wound has sufficient granulation tissue to support the graft.

Autologous skin graft is a painful procedure and moreover sometimes the recipient wound is so large that an autologous tissue graft would not be

sufficient.Skin substitutes are available nowadays that help in treating chronic wounds.

The damaged epithelial and dermal components of skin are replaced biologically by bioengineered skin substitutes that help in wound healing.They provide conditions and all the biological factors necessary for proper wound healing.

SKIN SUBSTITUES

The main advantage of skin substitutes is that they promote re-epithelialisation.They provide a protective covering preventing bacterial influx and at the same time allowing fluid and gaseous exchange.These are generally used prior to skin grafting or used temporarily as specialized dressings.

There are two types of skin substitutes,cellular and acellular types.Cellular skin substitutes contain fibroblasts and keratinocytes.They are incorporated in a collagen or polyglactin matrix.The acellular varieties contain only the matrix that are usually composed of fibronectin, hyaluronic acid or collagen.The matrix is so constructed that the host cells can freely pass through.A few skin substitutes incorporate into the wound itself forming a neodermis.

There are a variety of skin substitutes depending on the biological material used. The following describes some of the products currently available to treat burns wound and other skin wounds:

- alloDerm® (LifeCell Corporation, Branching, NJ, USA) – acellular, de-epithelialized cadaver dermis.
- Apligraf® (Organogenesis, Inc., Canton, MA, USA) – neonatal keratinocytes and collagen seeded with neonatal fibroblasts.
- Biobrane® (UDL Laboratories, Inc., Rockford, IL, USA) – Silicone,collagen and nylon mesh.
- Dermagraft® (Advanced BioHealing, Inc., Westport, CT, USA) – Polyglycolic acid or polyglactin – 910 seeded with neonatal fibroblasts.
- Epicel® (Genzyme Biosurgery, Cambridge, MA) – autologous cultured keratinocytes.
- GraftsJacket® (Wright Medical Technology, Inc., Arlington, TN, USA) – Freeze dried acellular human dermal matrix.
- Integra® Dermal Regeneration Template (Integra LifeSciences Holding Corp., South Plainsboro, NJ, USA) – silicone, collagen, and glycosaminoglycan
- Oasis® (Healthpoint Ltd., Fort Worth, TX, USA) – derived from porcine small intestinal submucosa.
- OrCel® (Forticell Bioscience, Inc., New York, NY, USA) – normal human allogeneic skin cells (epidermal keratinocytes and dermal fibroblasts) are cultured in two separate layers into a Type I bovine collagen sponge.

- Promogran® (Systagenix wound management, London, UK; Formerly marketed by the professional wound care business of Ethicon Inc, a Johnson & Johnson company) – bovine collagen and oxidized regenerated cellulose.

THE FUTURE

NPWT combines both open and closed modalities ot treatment and adheres to the principles of DeBakey in being short, safe, and simple. It is undoubtedly proved to be useful in a wide variety of wounds, but their use in general practice is clinician dependant and in many cases idiosyncratic.According to the Cochrane report,ther are no high quality trials conducted on this topic.Most of the studies done have small sample sizes and other methodological limitations such that the results are scrutinized with a lot of caution. Several random controlled trials are necessary to investigate these issues and this may be a challenging problem for people doing research in wound healing as there are a lot of difficulties in the assessing and measuring of healing in wounds.

NPW therapy is a highly beneficial method for a wide range of wound though it may not be useful in a few.NPWT has been compared to traditional dressing methods in terms of 'time to healing' or epithelialisation in other words but this is an inappropriate comparison as NPWT is mainly intended for wounds with heavy exudates or those with cavitary leiosions. NPWT is a useful tool in transforming a wound to a point where more Traditional dressings or simpler surgical methods for

reconstruction can be used.Although a pragmatic addition at present,NPWT is a well deserved addition to the armamentarium of wound healing and reconstruction.

MATERIALS AND METHODOLOGY

MATERIALS AND METHODS

DESIGN

Experimental study

SETTING

Study is conducted at Government Rajaji Hospital,Madurai which is a tertiary care centre. Patients are selected from general surgery wards.

PERIOD OF STUDY

One year extending from June 2013 to May 2014.

SAMPLE SIZE

Case are selected from the General surgery wards (ward 219 and ward 223), Government Rajaji Hospital,Madurai..

Cases and controls are selected from the same wards at different time period.

Total 25 cases and 25 controls, they were randomized by the admission.

INCLUSION CRITERIA

Patients included in study are classified according to the grade of the ulcer (wagner classification). All grades are included except grade 0 and 5.

- Age between 13 and 70 years.
- Diabetic ulcers
- Traumatic ulcers.

EXCLUSION CRITERIA

- Fistulas to organs or body cavities
- Necrotic tissue in eschar.
- Ostemyelitis (Untreated)
- Exposed blood vessels
- Gangrenous foot
- Active bleeding and patients undergoing anticoagulant therapy.
- Malignancy
- Patients below 13 years and above 70 years.

METHOD OF STUDY

During the period of study cases and controls selected from the general surgery wards. (ward 219 and 223)

After debridement of the wound, VAC dressing is applied after the bleeding gets stopped. Pre VAC and post VAC C & S is taken. Dressing is given for 72 hours and intermittent suction is given for ten minutes in an hour, daily for 12 hrs with a

negative pressure ranging from 100 to 125 mm of mercury. Rest of the time drain of the VAC dressing connected to the Romo vac suction drain.

Doppler study to assess the vascularity of the limb before the procedure and x-ray taken to rule out ostemyelitis.

Control group patients are given with conventional dressings.

OUTCOME VARIABLES

Difference in

- Rate of healing
- Hospital stay
- Pus C&S before & after V.A.C.

MATERIALS USED FOR STUDY

- Transparent, sterile material (OP-SITE)
- Transparent adhesive plaster
- Sponge (presterilzed)
- Suction drain with suction apparatus.

SEQUENCE OF PROCEDURE

1. Wound preparation
2. Placement of foam and drain
3. Sealing with drapes.

PROCEDURE

Patient selected for VAC therapy undergoes wound debridement and haemostasis is achieved. Pre VAC culture and X-ray to rule out active osteomyelitis is taken. A piece of pre sterilized foam (about one cm in thickness) is cut to the size of the wound and is placed on it. Then a perforated drainage tube (Romo vac suction drain tube is used here) is put on it. Again a piece of foam is placed on the underlying foam and tube. The whole foam with tube is covered with a sterilte transparent dressing (opsite). The tube is connected to a common suction apparatus with a pressure gradient.

Suction is applied with a negative pressure of 100 to 125 mm of Hg for 10 minutes hourly for 12 consecutive hours. Rest of the time this drainage tube is connected to the Romo vac suction apparatus. Dressing changed after 72 hours and post VAC culture is taken. There cycles of dressings and vaccum are applied statistical assessment is done using outcome variables.

STATISTICAL ANALYSIS

Data were analyzed using computer software, statistical package for social sciences (SPSS) version 12. Data are expressed in its comparison between controls and cases, chi squire (x^2) test was used as nonparametric test. Student's test was used to compare mean values between two groups. For all statistical evaluations, a two-tailed probability of value, <0.05 was considered significant.

ADHESIVE OCCLUSIVE DRESSING(OPSITE)

SUCTION DEVICE

ROMOVAC SUCTION DRAIN KIT

WOUND BEFORE APPLICATION OF VAC THERAPY

MOISTENED GAUZE OVER THE WOUND

STERILISED FOAM

FOAM APPROXIMATED TO WOUND SIZE

ROMOVAC SUCTION TUBING PLACED OVER THE FOAM

CHARACTERISTIC APPERANCE OF VAC DRESSING SITE WITH SUCTION IN ACTION

CONTINUOUS SUCTION THERAPY

INTERMITTENT SUCTION THERAPY

WOUND AFTER APPLICATION OF VAC THERAPY

OBSERVATIONS AND DISCUSSIONS

OBSERVATIONS AND DISCUSSION

Table 1. Gender distribution and its association with group

Gender	Group		Total
	Control	Cases	
Male	18 72.00%	14 56.00%	32 64.00%
Female	7 28.00%	11 44.00%	18 36.00%
Total	25	25	50
Chi Square : 1.389; P> 0.05			

Male and female distribution was almost equal in control and cases. 72% and 56% of the control and cases population respectively were males where as 44% of the cases were females. The gender difference between groups was not found to be statistically significant.

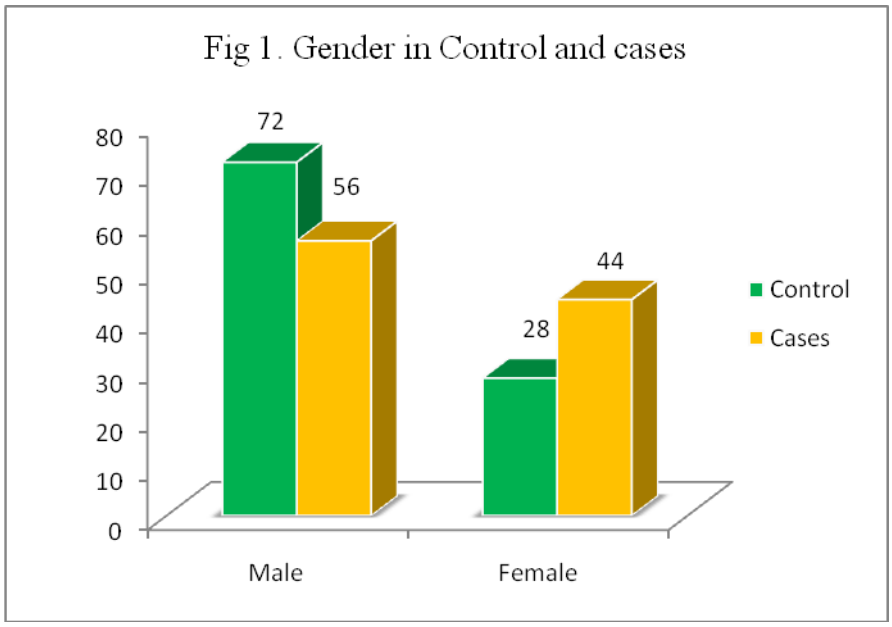
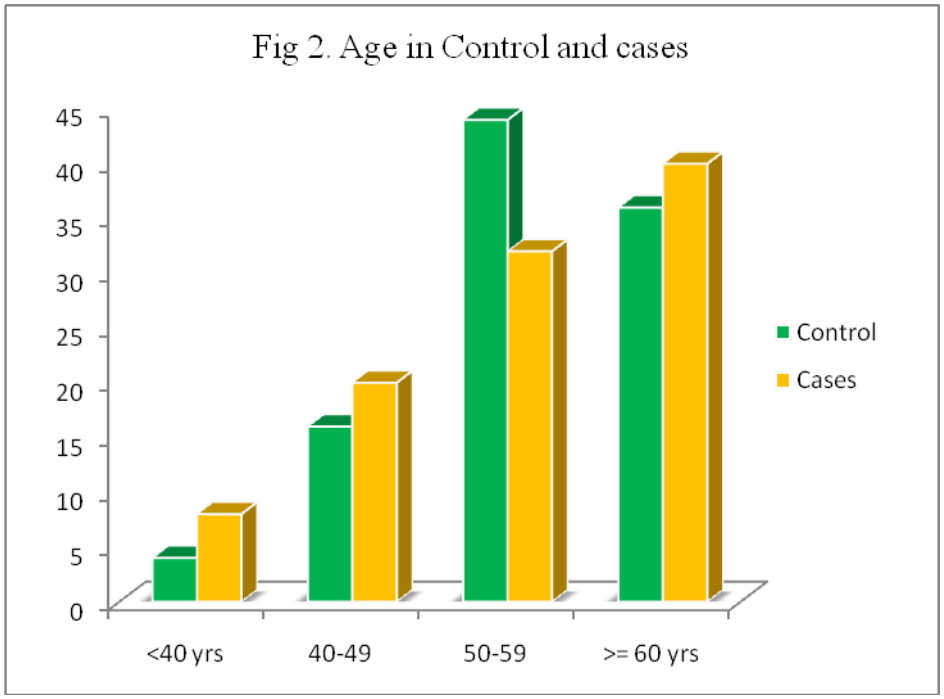


Table 2. Gender distribution and its association with group

Age	Group		Total
	Control	Cases	
<40 yrs	1 4.00%	2 8.00%	3 6.00%
40-49	4 16.00%	5 20.00%	9 18.00%
50-59	11 44.00%	8 32.00%	19 38.00%
Chi Square : 1.389; P> 0.05			

Age Not significant



Age distribution was almost equal in control and case groups. Chi-square test shows no statistical significance as ‘p’ value is more than 0.05.

Table 3. Gender distribution and its association with group

Duration of Hospital Stay (Days)	Group		Total
	Control	Cases	
7-14	1 4.00%	6 24.00%	7 14.00%
14-21	2 8.00%	7 28.00%	9 18.00%
21-28	10 40.00%	6 24.00%	16 32.00%
28-35	6 24.00%	5 20.00%	11 22.00%
>35 days	6 24.00%	1 4.00%	7 14.00%
Total	25	25	50

Chi square : 11.012; P<0.05

COMPARISON OF MEAN AGE AND DURATION OF HOSPITAL STAY (DAYS) BETWEEN CASES AND CONTROLS

Parameter	Group	Mean	± SD	t value	p value
Age (years)	Control	56.2	8.5147	0.159	>0.05
	Cases	55.8	9.2331		
Duration of Hospital Stay (Days)	Control	30.4	9.3897	3.131	<0.01
	Cases	22.2	9.1287		

Duration of hospital stay highly significant

Duration of hospital stay in days was found to be statistically significant between groups. Control population stayed more days in hospital than cases. Majority (52%) of the cases left hospital within three weeks time, whereas major chunk (88%) of control population stayed more than three weeks time

High –pressure suction drainage via a polyurethane foam in the management of posternotomy mediastinitis by Pedro A. Catarino.

(Appedix 1:2)

A Blinded, Prospective, Randomized Controlled Trial of Topical Negative pressure wound closure in India. Author : Gita N. Mody.

(Appedix 1:3)

Have similar result of faster healing rate and less hospital stay.

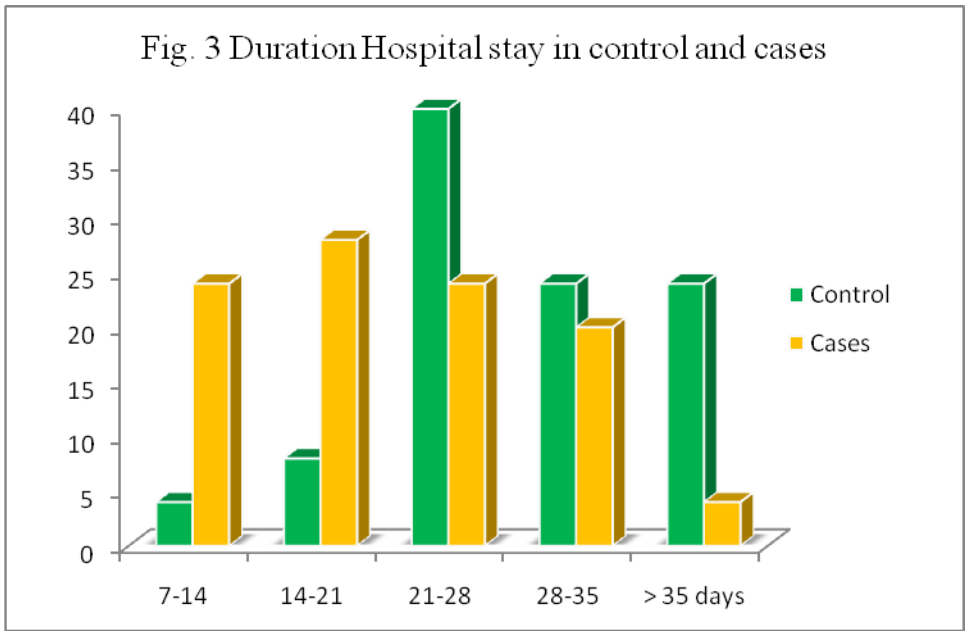
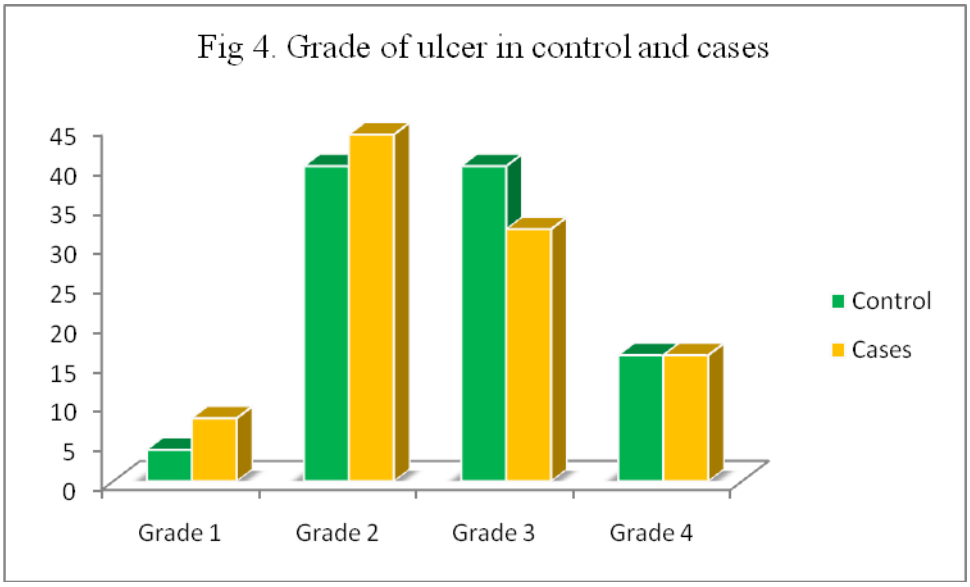


Table 4 : GRADE OF THE ULCER

Grade of Ulcer	Group		Total
	Control	Cases	
Grade 1	1 4.00%	2 8.00%	3 6.00%
Grade 2	10 40.00%	11 44.00%	21 42.00%
Grade 3	10 40.00%	8 32.00%	18 36.00%
Grade 4	4 16.00%	4 16.00%	8 16.00%
Total	25	25	50
Chi square : 0.603; P> 0.05			

Not Significant

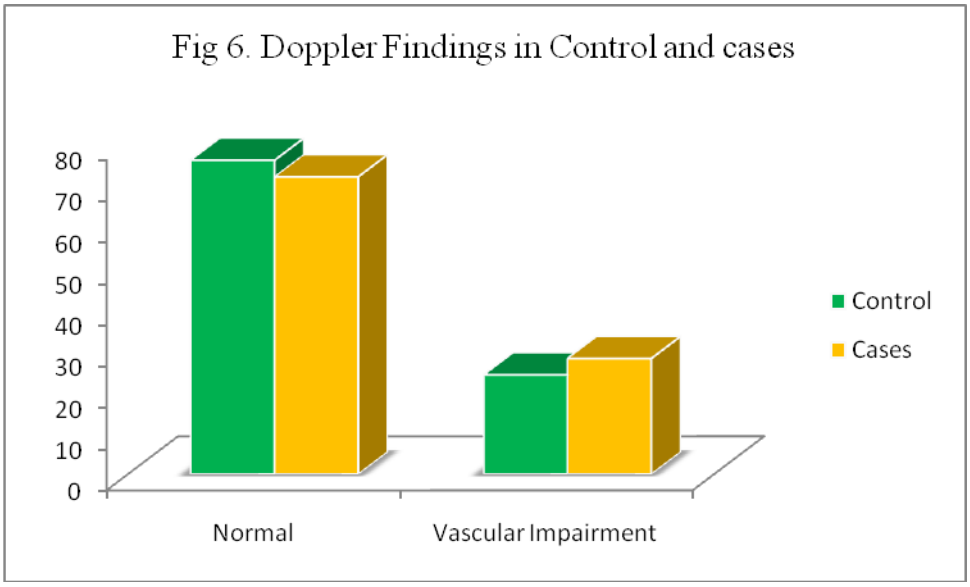


Grade of the Ulcer distribution was almost equal in cases and control. Chi-square test shows 'P' value is more than 0.05. which is statistically not significant.

Table 5 : DOPPLER FINDINGS IN CASES AND CONTROL.

Doppler Finding	Group		Total
	Control	Cases	
Normal	19 76.00%	18 72.00%	37 74.00%
Vascular Impairment	6 24.00%	7 28.00%	13 26.00%
Total	25	25	50
Chi Square : 0.104; P> 0.05			

Not Significant

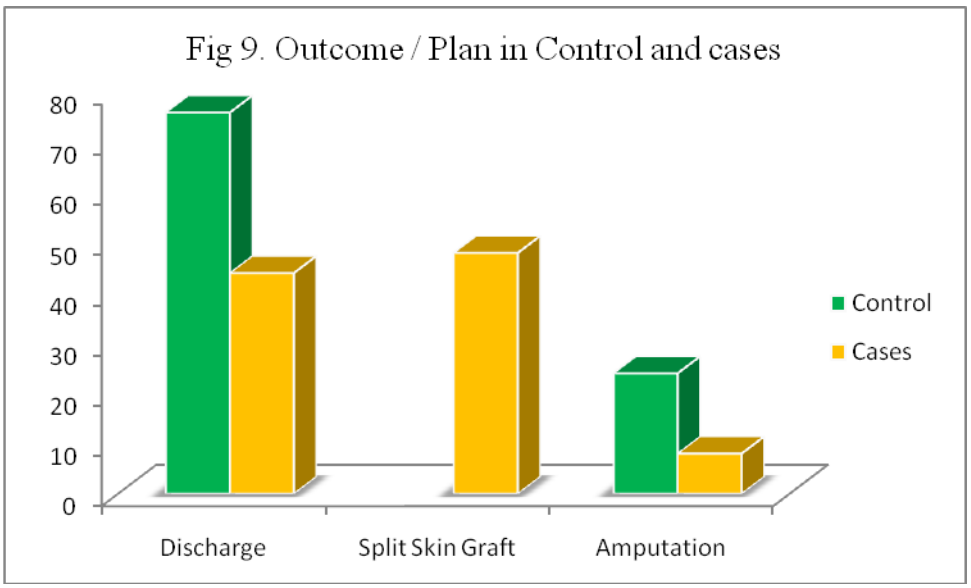


Chi-square test shows study is not significant as ‘p’ value is more than 0.05. So VAC dressing has almost similar effect on normal Dopplere study in case and control Gropu. But VAC dressing shows better results in patients with normal Doppler study.

Table 6 : ANALYSIS OF CASES AND CONTROL GROUPS IN OUTCOME / PLAN

Outcome /Plan	Group		Total
	Control	Cases	
Discharge	19 76.00%	11 44.00%	30 60.00%
Split Skin Graft		12 48.00%	12 24.00%
Amputation	6 24.00%	2 8.00%	8 16.00%
Total	**25**	**25**	**50**
Chi Square : 16.133; P> 0.001			

Very highly significant



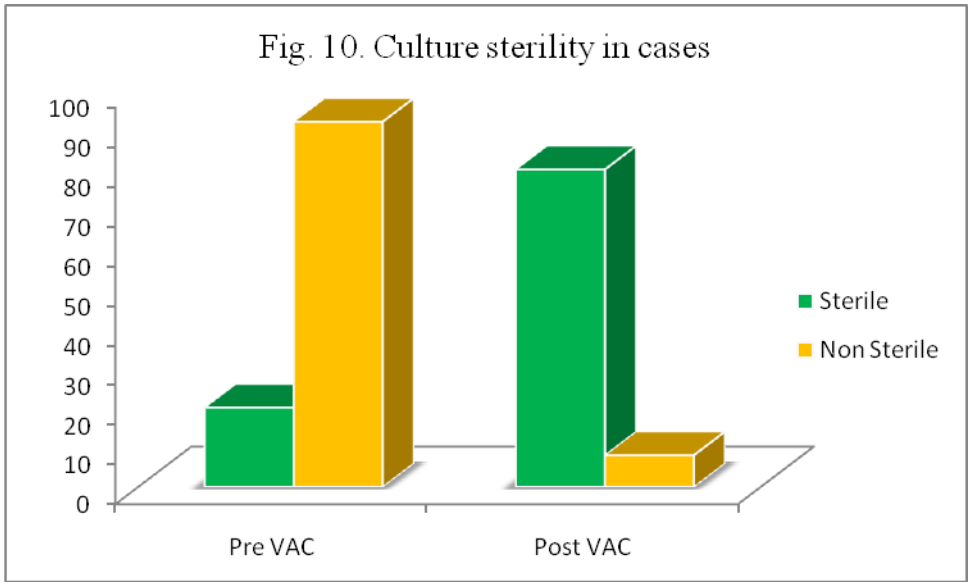
Chi-square test shows study is significant as p-value is less than 0.001. So VAC dressing have better results in patients, VAC dressing produces more split skin grafts before discharge and less rate of amputation.

Table 7 : ANALYSIS OF CULTURE STERILITY IN PRE-VAC AND POST-VAC STATE

Culture Sterility in cases	Group		Total
	Pre VAC	Post VAC	
Sterile	5 20.00%	23 92.00%	28 56.00%
Non sterile	20 80.00%	2 8.00%	22 44.00%
Total	25	25	50

Chi square : 26.299; P <0.001

Very highly significant



Chi-square test shows significatnt statistical association as p-value is less than 0.001. patients with sterile pre-VAC cultue is not turining unsterilte after VAC. But 90% unsterilte turns sterile after VAC.

Indian J Plast Surg. 2009 Jul – Dec; 42(2) : 161-168.

Morykwas MJ, Argenta LC, Shelton – Brown El, et al.

The bacteriological and cytological assessment of VAC on purulent wounds : by Davydov YA

Has shown efficacy of VAC in turning pus C & S Sterile

Above described studies had shown the efficacy of VAC dressing over conventional dressing and its better outcome. More than this VAC dressing decreases hospital expenses, hospital waster, nursing care required.

CONCLUSION

CONCLUSION

- V.A.C dressing decreases Hospital stay
- V.A.C dressing improves pus culture sterility
- V.A.C dressing improves outcome by decreasing the number of amputations and increasing the number of patients undergoing skin grafting.
- V.A.C dressing has better result in patients with Normal Doppler
- V.A.C dressing has good result in patients with non active osteomyelitis

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PROFORMA

Vacuum assisted closure

Name	:	
Age	:	
Sex	:	M/F
IP No.	:	
Date of Admission	:	
Date of Discharge	:	
Duration	:	
DM	:	Y/N
Alcoholic	:	Y/N
Co morbid medical conditions	:	
History of present ulcer	:	

Examination of ulcer

Site	:
Size	:
Shape	:
Margine	:
Floor	:
Base	:

VASCULAR STATUS

Skin	:
Pulse	:

INVESTIGATIONS

Hb :

TC DC PLME Blood Group

S.Ca S-Bilirubin S-Albumin

RBS at the time of admission :

FBS / PPBS :

Blood urea / S.Creatinine :

Fasting lipid profile :

ECG :

Doppler ultra profile :

X-ray study :

Viral markers :

Pre and post C & S :

TREATMENT

Antibiotics (if any) :

Insulin Dosage :

Any OHA :

Treatment before VAC :

Blood Transfusion (if any) :

ABOUT VAC

NO.OF APPLICATION

METHOD USED

VAC	1	2	3

Date of Application			
Date if Removal			

AFTER VAC

Granulation : Y/N

Exudate : C&S

PLAN AFTER VAC

DIAGNOSIS

(All findings observed will be recorded in the Proforma. Appropriate statistical evaluation will be done at the end of the study).

MASTER CHART

S.NO	NAME	AGE	SEX	I.P NO	HOSPITAL STAY	ULCER GRADE	DOPPLER STUDY	PRE VAC C&S	POST VAC C&S	OUITCOME/PLAN
1	Saamiappan	65	M	11245	14	1	No vascular impairment			Discharged
2	Vadivu	55	F	54261	28	2	No vascular impairment			Discharged
3	Muthuvel	63	M	89456	22	2	No vascular impairment			Discharged
4	Arokiyasamy	61	M	24513	25	3	Vascular impairment			Discharged
5	Baskaran	54	M	12459	27	3	No vascular impairment			Discharged
6	Koodalingam	41	M	246698	32	2	No vascular impairment			Discharged
7	Kannan	59	M	21022	48	4	No vascular impairment			Amputation
8	Sakthivel	62	M	124569	26	2	No vascular impairment			Discharged
9	Chidambaram	57	M	2150	18	2	No vascular impairment			Discharged
10	Dheivayaani	53	F	124523	30	3	No vascular impairment			Discharged
11	Paapammal	52	F	78469	42	3	Vascular impairment			Amputation
12	Ponnuthaai	67	F	14256	24	2	No vascular impairment			Discharged
13	Suresh	68	M	12546	28	3	No vascular impairment			Discharged
14	Veeranan	59	M	87546	54	4	Vascular impairment			Amputation
15	Maarimuthu	65	M	21563	32	3	Vascular impairment			Discharged
16	Raja Veeran	51	M	54665	24	2	No vascular impairment			Discharged
17	Mary	46	F	58885	30	2	No vascular impairment			Discharged
18	Shakunthala	51	F	78562	34	3	Vascular impairment			Amputation
19	Sahayan	61	M	1203	24	2	No vascular impairment			Discharged
20	Mahalakshmi	62	F	12056	21	2	No vascular impairment			Discharged
21	Krishnakumar	42	M	21056	39	3	No vascular impairment			Discharged
22	Shakeel	58	M	89565	38	4	No vascular impairment			Amputation
23	Kurunjinathan	54	M	47852	34	3	No vascular impairment			Discharged
24	Gopal	44	M	55556	42	4	Vascular impairment			Amputation
25	Manivannan	28	M	45213	24	3	No vascular impairment			Discharged
26	Gomathi	41	F	21536	9	2	No vascular impairment			Discharged
27	Kamal	52	M	98762	34	4	Vascular impairment	Unsterile	Sterile	Amputation
28	Mookaiyyan	51	M	56232	11	2	No vascular impairment	Sterile	Sterile	Discharged
29	Usha	67	F	45896	10	2	No vascular impairment	Unsterile	Sterile	Discharged
30	Indhumathi	63	F	65464	20	3	No vascular impairment	Unsterile	Sterile	SSG
31	Chokaiya	44	M	11124	28	2	No vascular impairment	Unsterile	Sterile	SSG
32	Kurumban	28	M	45896	12	2	No vascular impairment	Unsterile	Sterile	**Discharged**

33	Vadivu	59	M	77774	46	4	Vascular impairment	Unsterile	Sterile	SSG
34	Lloyds	62	M	84596	31	3	No vascular impairment	Unsterile	Sterile	SSG
35	Ganesh	61	M	14263	13	2	No vascular impairment	Unsterile	Sterile	Discharged
36	Sukanya	48	F	1235	29	3	Vascular impairment	Unsterile	Sterile	SSG
37	Aandal	32	F	6588	22	2	No vascular impairment	Sterile	Sterile	Discharged
38	Saravanan	53	M	6598	28	1	No vascular impairment	Sterile	Sterile	Discharged
39	Raasuvel	69	M	12458	15	1	No vascular impairment	Unsterile	Sterile	SSG
40	Raajathi	44	F	99996	27	3	Vascular impairment	Unsterile	Sterile	SSG
41	Mookayee	63	F	78546	28	3	No vascular impairment	Unsterile	Sterile	SSG
42	Paavaendher	65	M	124563	15	2	No vascular impairment	Sterile	Sterile	Discharged
43	Palaniappan	57	M	12458	20	2	Vascular impairment	Unsterile	Sterile	Discharged
44	Palaniammal	58	F	45623	14	2	No vascular impairment	Unsterile	Sterile	SSG
45	Noor Jahan	49	F	21035	30	4	Vascular impairment	Unsterile	Sterile	SSG
46	Jithan	74	M	12456	21	2	No vascular impairment	Unsterile	Sterile	SSG
47	Puliyan	66	M	57840	32	3	Vascular impairment	Unsterile	Sterile	SSG
48	Kathiresan	62	M	96532	26	4	No vascular impairment	Unsterile	Sterile	Amputation
49	Rani	53	F	341256	18	3	No vascular impairment	Unsterile	Sterile	Discharged
50	Poovathaal	56	F	63012	16	3	No vascular impairment	Unsterile	Sterile	Discharged